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Maki

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(54) **EMBROIDERY DATA GENERATOR, SEWING MACHINE AND NON-TRANSITORY COMPUTER-READABLE STORAGE MEDIUM**

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D05B 19/12 (2006.01)
D05B 19/02 (2006.01)

(52) **U.S. Cl.**
CPC ***D05B 19/12*** (2013.01); ***D05B 19/02*** (2013.01)

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CPC D05B 19/02; D05B 19/04; D05B 19/08; D05B 19/085; D05B 19/10; D05B 19/105; D05C 5/00; D05C 5/02
USPC 700/136–138; 112/102.5, 470.01, 112/470.04, 475.19
See application file for complete search history.

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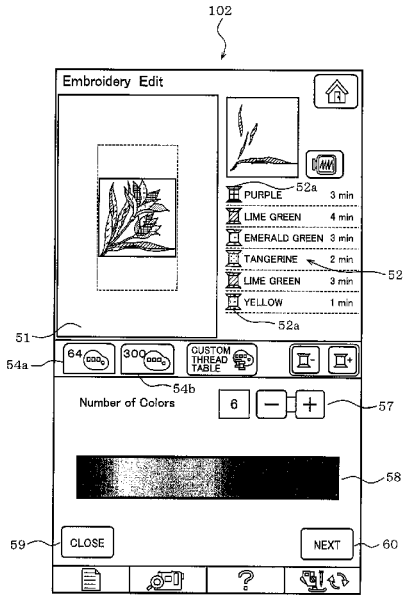
(57) **ABSTRACT**

An embroidery data generator generating embroidery data on which an embroidery pattern is sewn includes a display unit configured to be capable of color display, a control device configured to cause the display unit to display a color chart representing at least one of three attributes of hue, saturation and value of a color, to set a range on the color chart displayed by the display unit, to randomly extract one of colors within the set range, the one color being used as thread color data, the embroidery pattern including a plurality of color-based pattern portions, the thread color data specifying colors of the color-based pattern portions, and to assign the extracted color to the thread color data of a corresponding one of the color-based pattern portions.

11 Claims, 15 Drawing Sheets



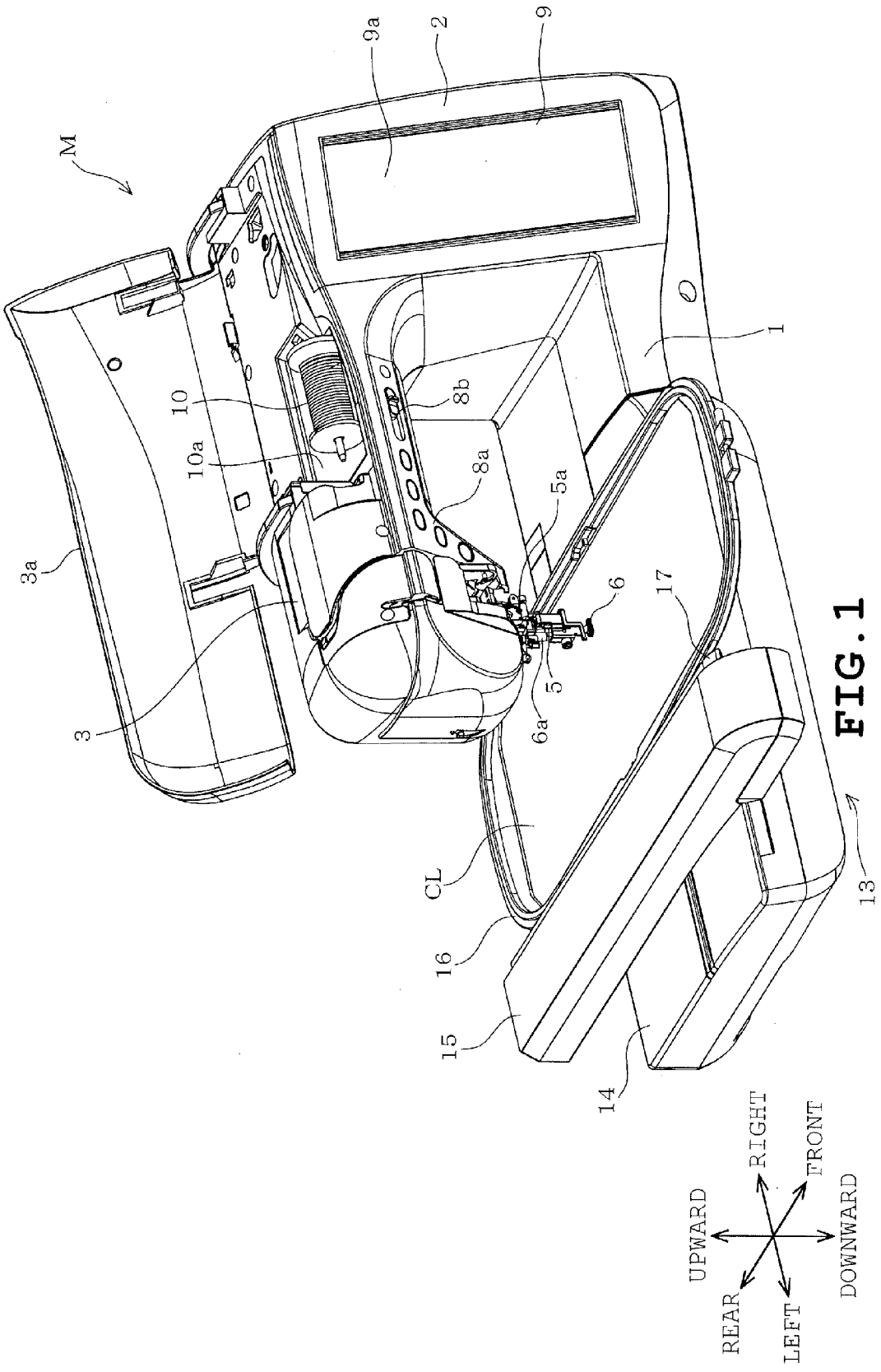

M
9a
2
9
1
10
10a
8b
8a
5a
3a
6
17
5
6a
3
CL
16
15
14
13
UPWARD
RIGHT
FRONT
REAR
LEFT
DOWNWARD

FIG. 1

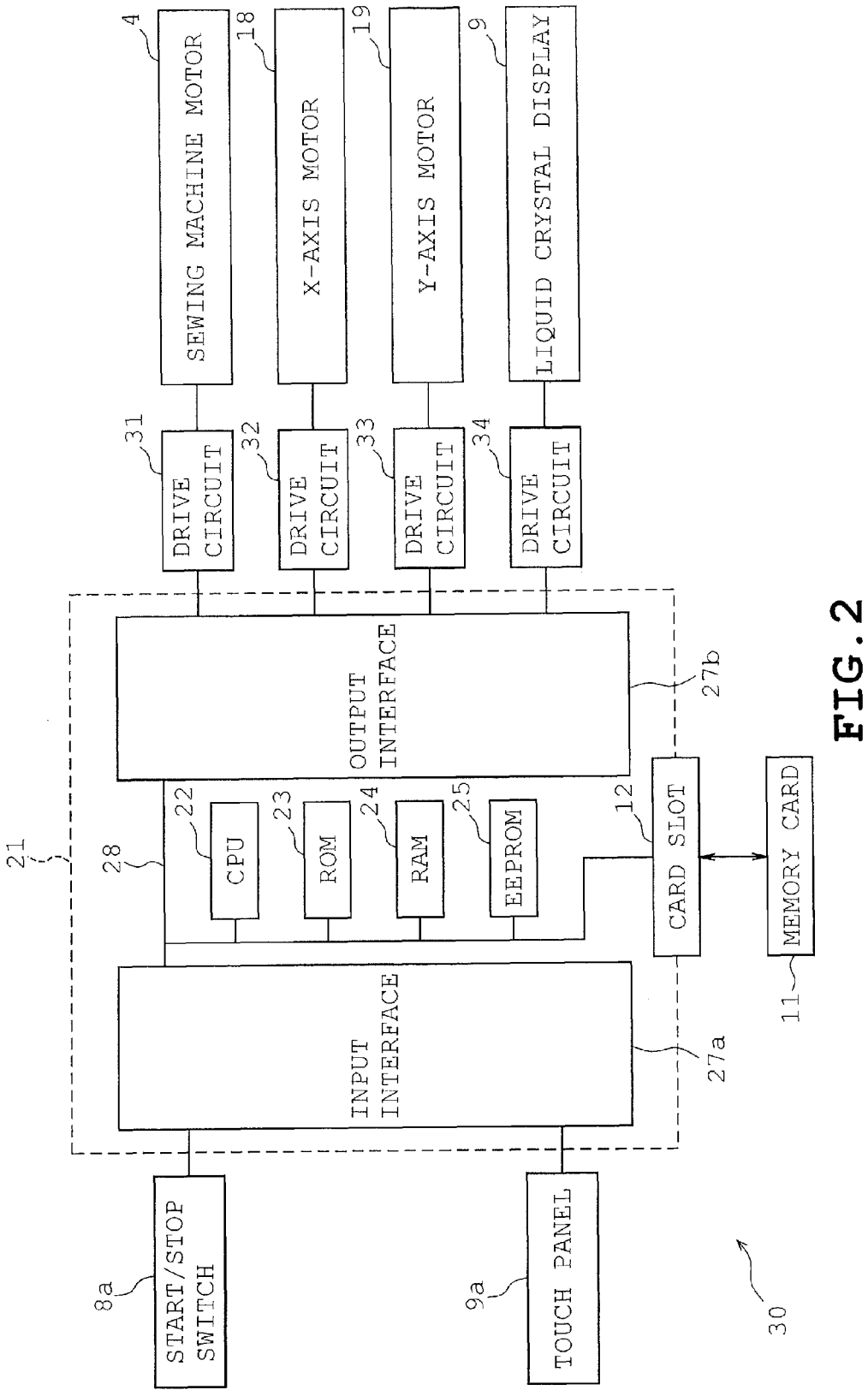

4
SEWING MACHINE MOTOR
18
X-AXIS MOTOR
19
Y-AXIS MOTOR
9
LIQUID CRYSTAL DISPLAY
31
DRIVE CIRCUIT
32
DRIVE CIRCUIT
33
DRIVE CIRCUIT
34
DRIVE CIRCUIT
OUTPUT INTERFACE
27b
21
28
22
CPU
23
ROM
24
RAM
25
EEPROM
12
CARD SLOT
MEMORY CARD
11
INPUT INTERFACE
27a
8a
START/STOP SWITCH
9a
TOUCH PANEL
30

FIG. 2

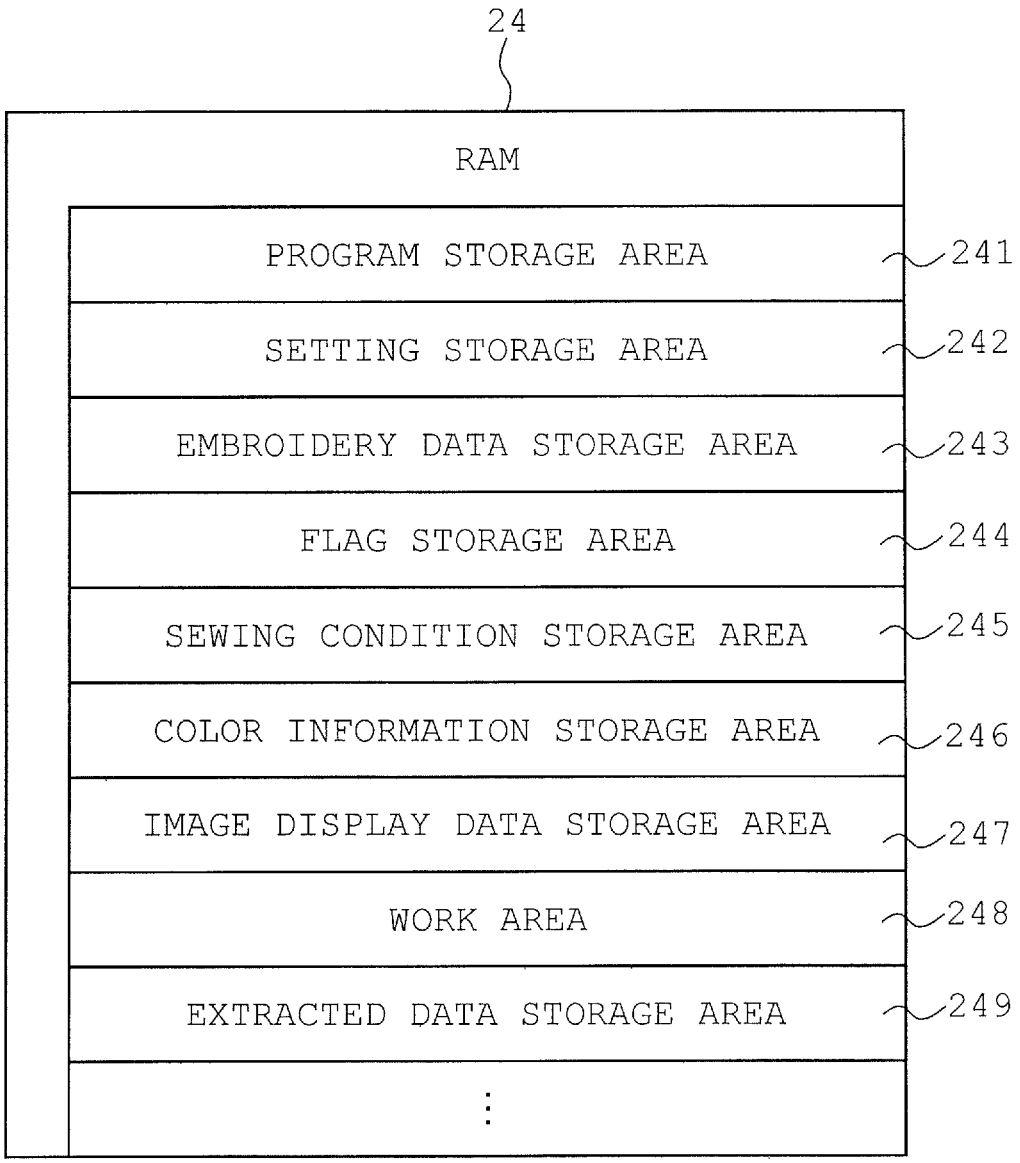

24
RAM
PROGRAM STORAGE AREA
241
SETTING STORAGE AREA
242
EMBROIDERY DATA STORAGE AREA
243
FLAG STORAGE AREA
244
SEWING CONDITION STORAGE AREA
245
COLOR INFORMATION STORAGE AREA
246
IMAGE DISPLAY DATA STORAGE AREA
247
WORK AREA
248
EXTRACTED DATA STORAGE AREA
249

FIG. 3

EMBROIDERY DATA	
FIRST PATTERN PORTION DATA	PATTERN 1 PURPLE
	Xa0, Ya0
	Xa1, Ya1
	Xa2, Ya2
	⋮
	XaN, YaN
SECOND PATTERN PORTION DATA	PATTERN 2 LIME GREEN
	Xb0, Yb0
	Xb1, Yb1
	Xb2, Yb2
	⋮
	XbN, YbN
THIRD PATTERN PORTION DATA	PATTERN 3 GREEN
	Xc0, Yc0
	Xc1, Yc1
	Xc2, Yc2
	⋮
	XcN, YcN
⋮	⋮
n-TH PATTERN PORTION DATA	PATTERN n YELLOW
	Xn0, Yn0
	Xn1, Yn1
	Xn2, Yn2
	⋮
	XnN, YnN

FIG. 4

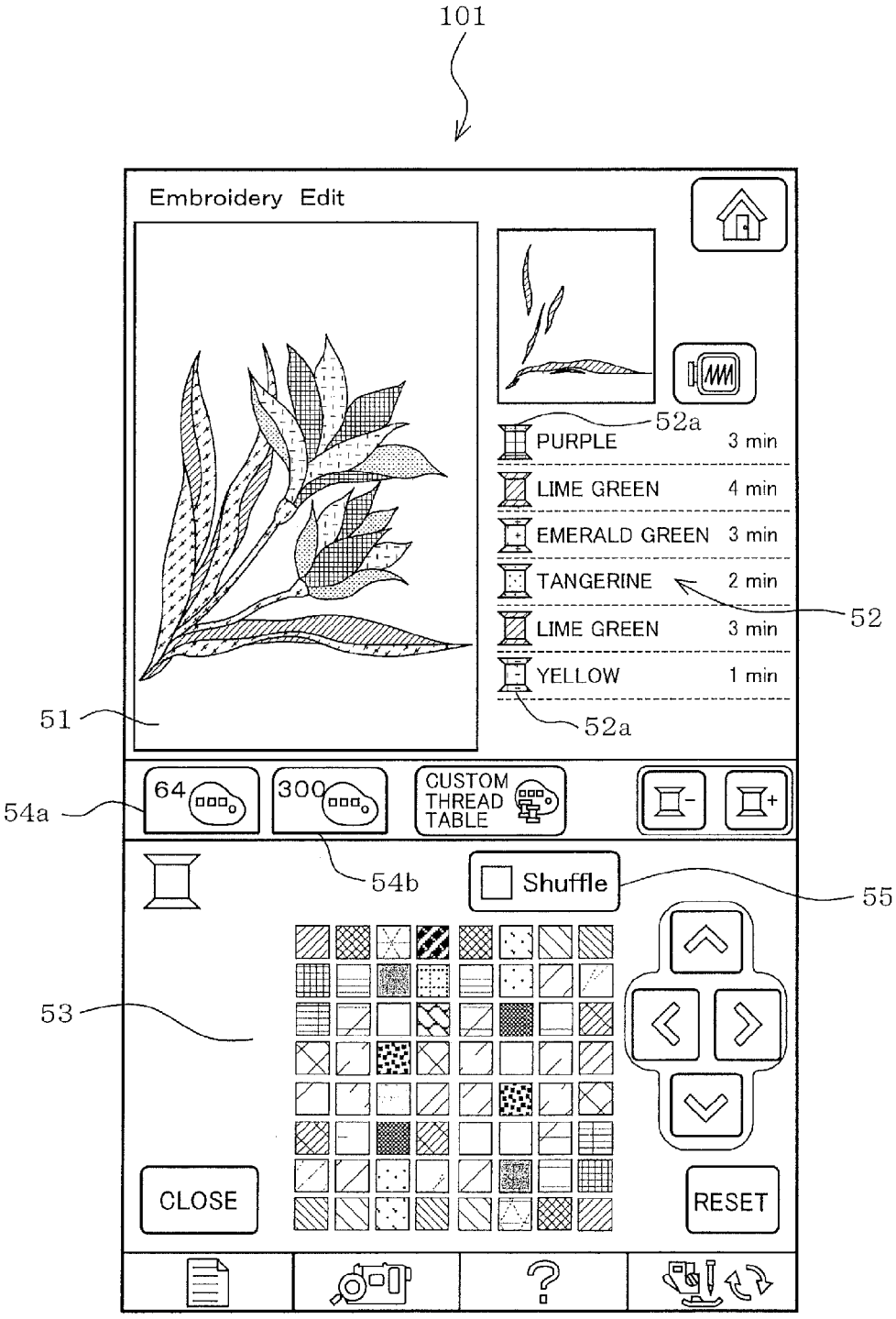

101
Embroidery Edit
PURPLE 3 min
LIME GREEN 4 min
EMERALD GREEN 3 min
TANGERINE 2 min
LIME GREEN 3 min
YELLOW 1 min
52a
52
51
64
300
CUSTOM THREAD TABLE
54a
54b
Shuffle
55
53
CLOSE
RESET

FIG. 5

FIG. 6A

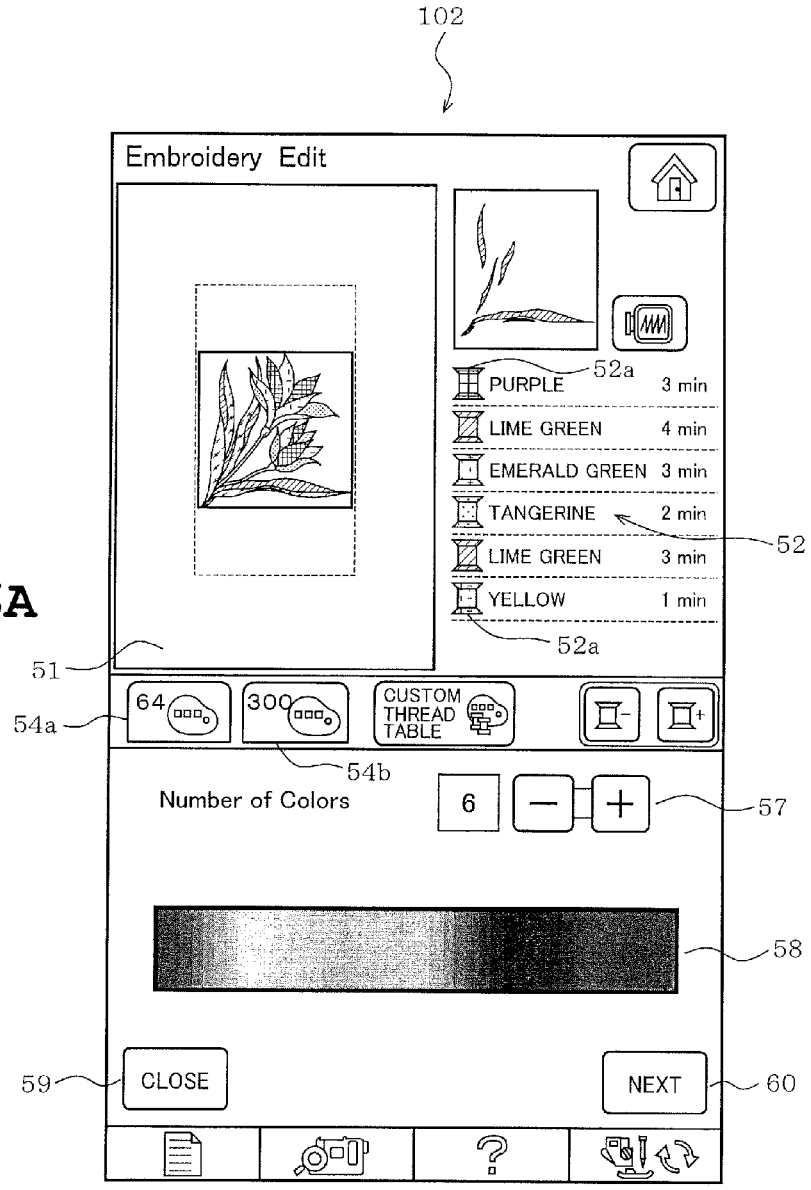
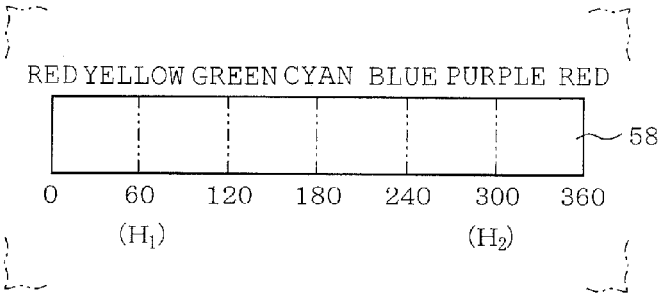

102
Embroidery Edit
PURPLE 3 min
LIME GREEN 4 min
EMERALD GREEN 3 min
TANGERINE 2 min
LIME GREEN 3 min
YELLOW 1 min
52a
52
51
64
300
CUSTOM THREAD TABLE
54a
54b
Number of Colors
6
57
58
CLOSE
59
NEXT
60

FIG. 6B


RED YELLOW GREEN CYAN BLUE PURPLE RED
58
0 60 120 180 240 300 360
(H1)
(H2)

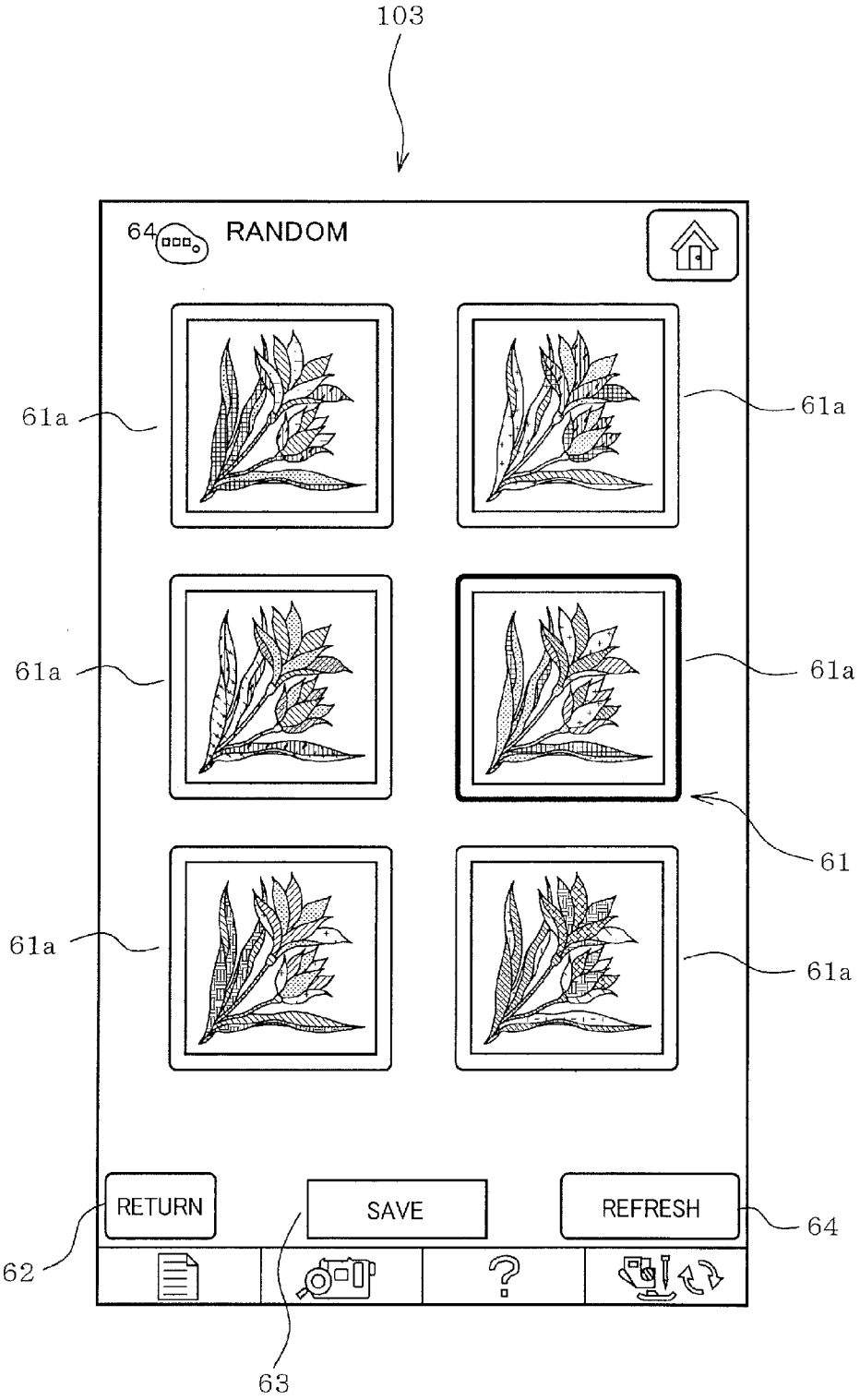

103
64
RANDOM
61a
61a
61a
61a
61a
61a
61
RETURN
SAVE
REFRESH
64
62
63

FIG. 7

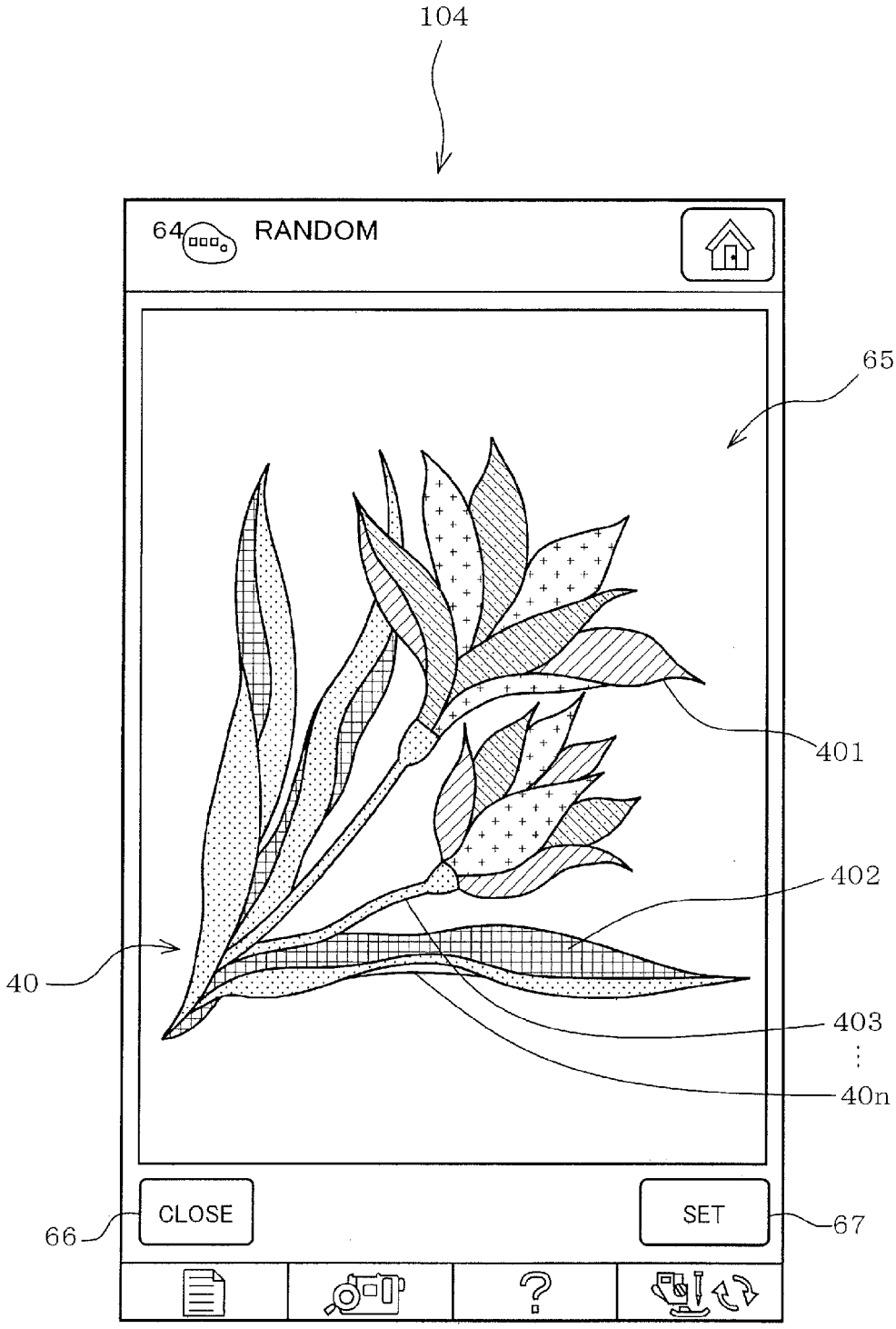


FIG. 8

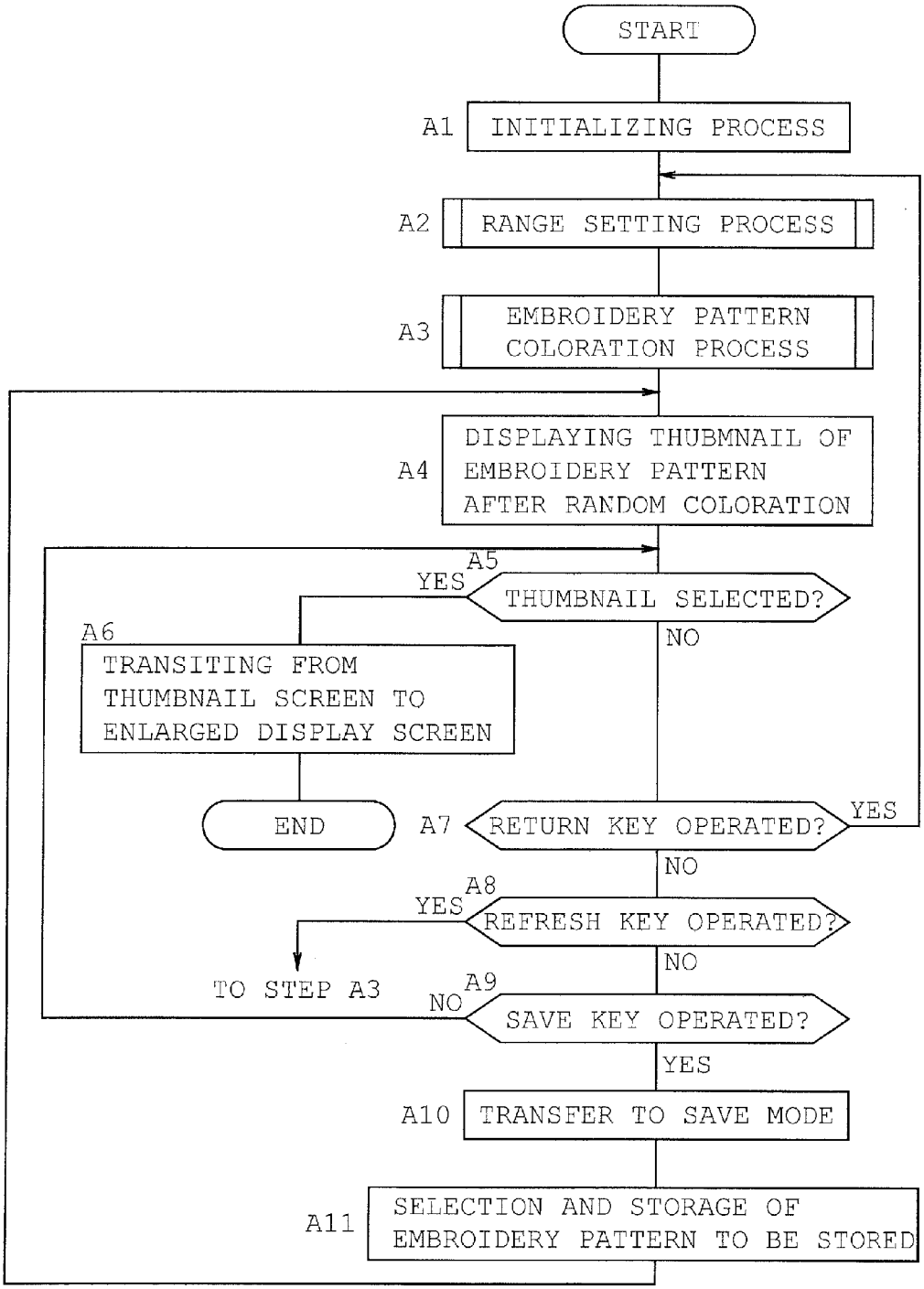

START
A1
INITIALIZING PROCESS
A2
RANGE SETTING PROCESS
A3
EMBROIDERY PATTERN COLORATION PROCESS
A4
DISPLAYING THUBMNAIL OF EMBROIDERY PATTERN AFTER RANDOM COLORATION
A5
YES
THUMBNAIL SELECTED?
NO
A6
TRANSITING FROM THUMBNAIL SCREEN TO ENLARGED DISPLAY SCREEN
END
A7
RETURN KEY OPERATED?
YES
NO
A8
YES
REFRESH KEY OPERATED?
NO
TO STEP A3
A9
NO
SAVE KEY OPERATED?
YES
A10
TRANSFER TO SAVE MODE
A11
SELECTION AND STORAGE OF EMBROIDERY PATTERN TO BE STORED

FIG. 9

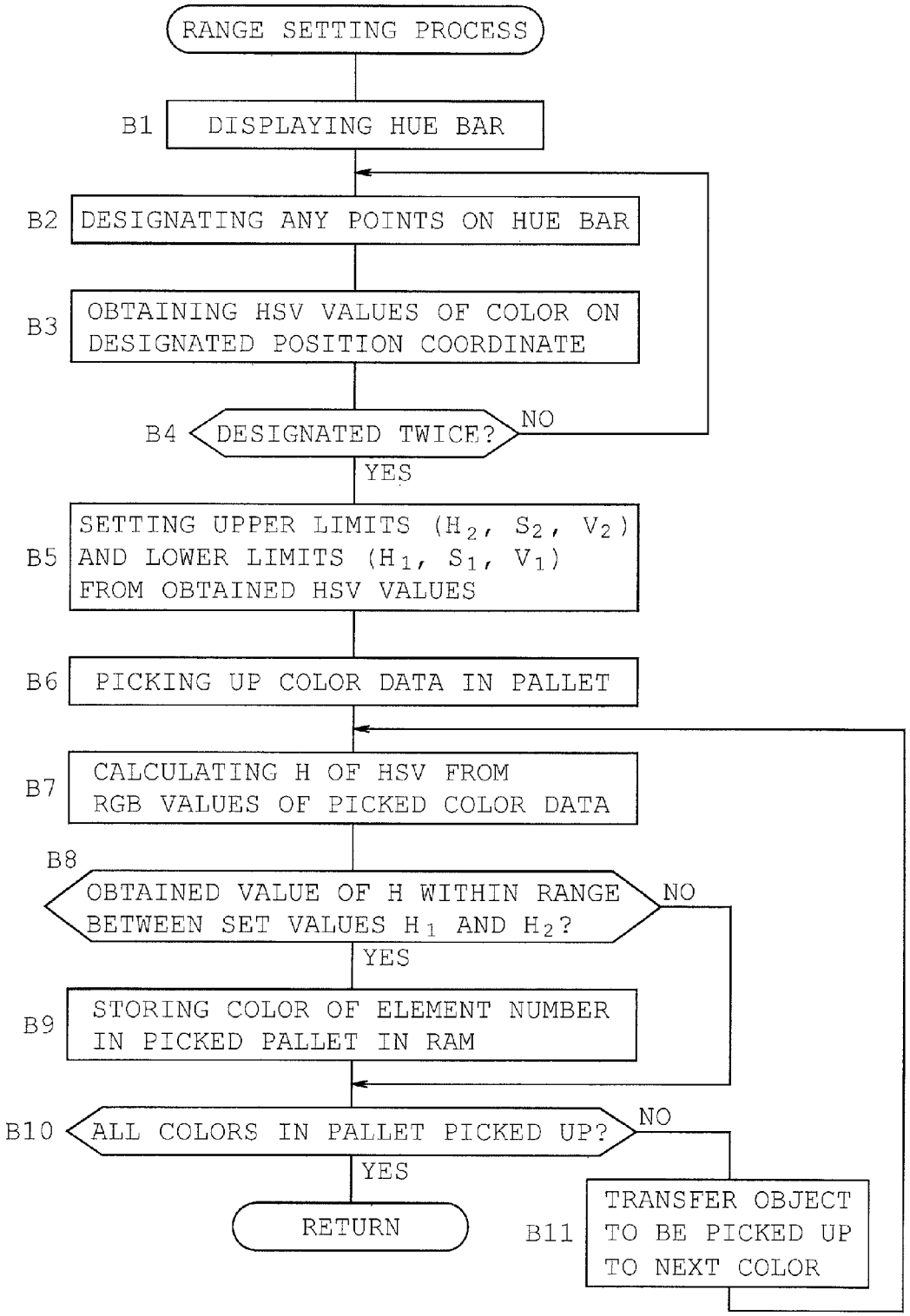

RANGE SETTING PROCESS
B1
DISPLAYING HUE BAR
B2
DESIGNATING ANY POINTS ON HUE BAR
B3
OBTAINING HSV VALUES OF COLOR ON DESIGNATED POSITION COORDINATE
B4
DESIGNATED TWICE?
NO
YES
B5
SETTING UPPER LIMITS (H2, S2, V2) AND LOWER LIMITS (H1, S1, V1) FROM OBTAINED HSV VALUES
B6
PICKING UP COLOR DATA IN PALLET
B7
CALCULATING H OF HSV FROM RGB VALUES OF PICKED COLOR DATA
B8
OBTAINED VALUE OF H WITHIN RANGE BETWEEN SET VALUES H1 AND H2?
NO
YES
B9
STORING COLOR OF ELEMENT NUMBER IN PICKED PALLET IN RAM
B10
ALL COLORS IN PALLET PICKED UP?
NO
YES
RETURN
B11
TRANSFER OBJECT TO BE PICKED UP TO NEXT COLOR

FIG.10

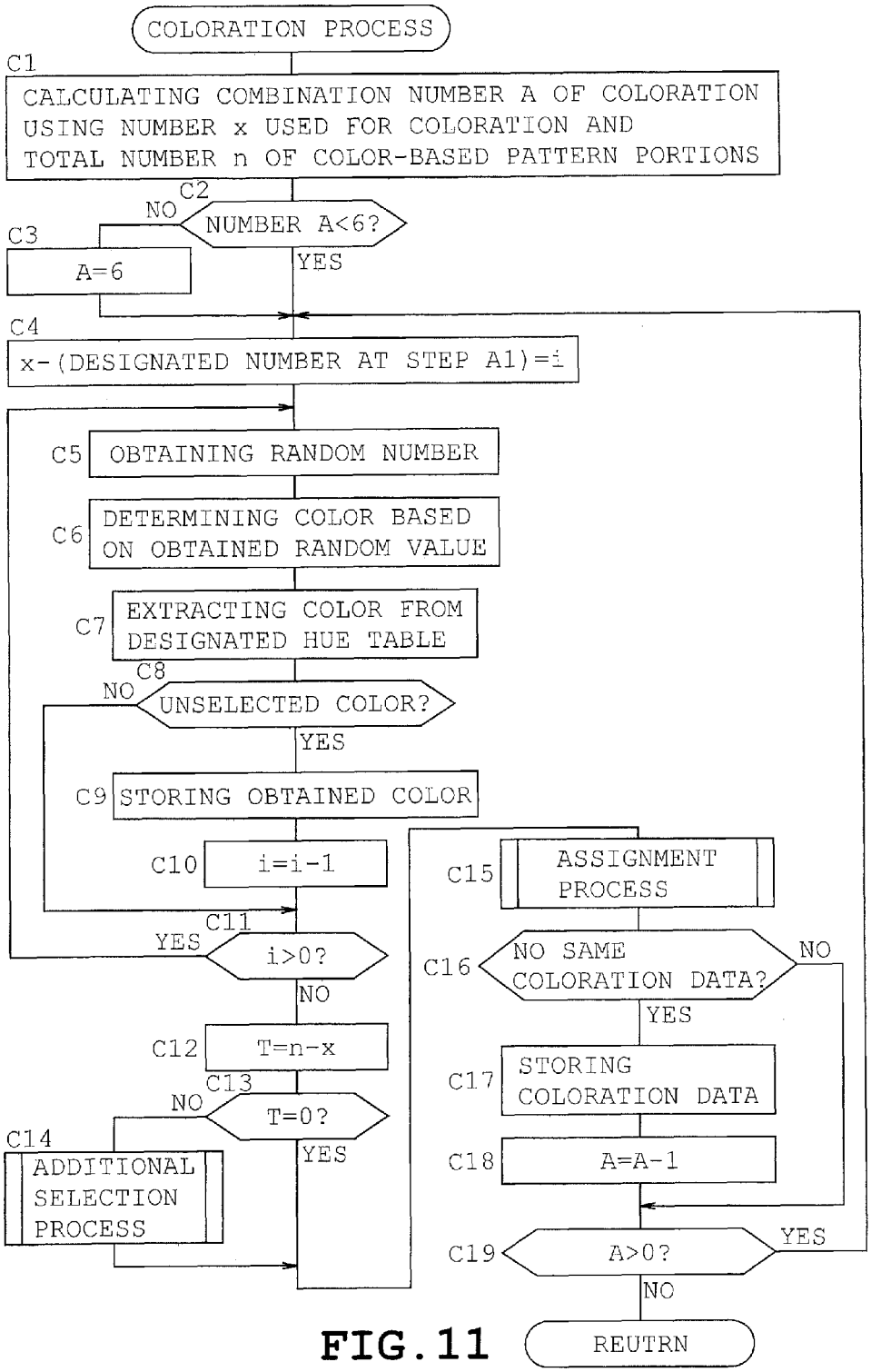

COLORATION PROCESS
C1
CALCULATING COMBINATION NUMBER A OF COLORATION USING NUMBER x USED FOR COLORATION AND TOTAL NUMBER n OF COLOR-BASED PATTERN PORTIONS
C2
NO
NUMBER A<6?
C3
A=6
YES
C4
x-(DESIGNATED NUMBER AT STEP A1)=i
C5
OBTAINING RANDOM NUMBER
C6
DETERMINING COLOR BASED ON OBTAINED RANDOM VALUE
C7
EXTRACTING COLOR FROM DESIGNATED HUE TABLE
C8
NO
UNSELECTED COLOR?
YES
C9
STORING OBTAINED COLOR
C10
i=i-1
C11
YES
i>0?
NO
C12
T=n-x
C13
NO
T=0?
YES
C14
ADDITIONAL SELECTION PROCESS
C15
ASSIGNMENT PROCESS
C16
NO SAME COLORATION DATA?
NO
YES
C17
STORING COLORATION DATA
C18
A=A-1
C19
A>0?
YES
NO
REUTRN

FIG. 11

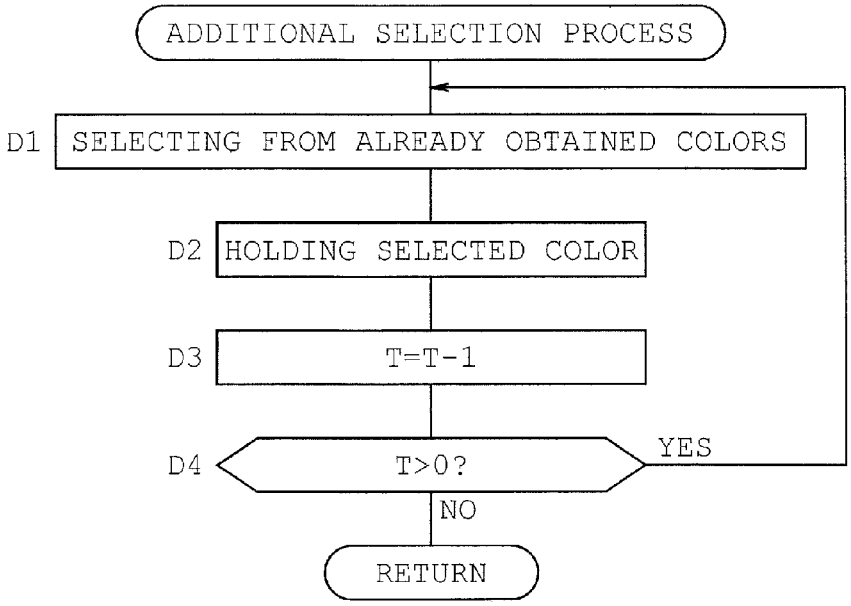

ADDITIONAL SELECTION PROCESS
D1
SELECTING FROM ALREADY OBTAINED COLORS
D2
HOLDING SELECTED COLOR
D3
T=T-1
D4
T>0?
YES
NO
RETURN

FIG.12

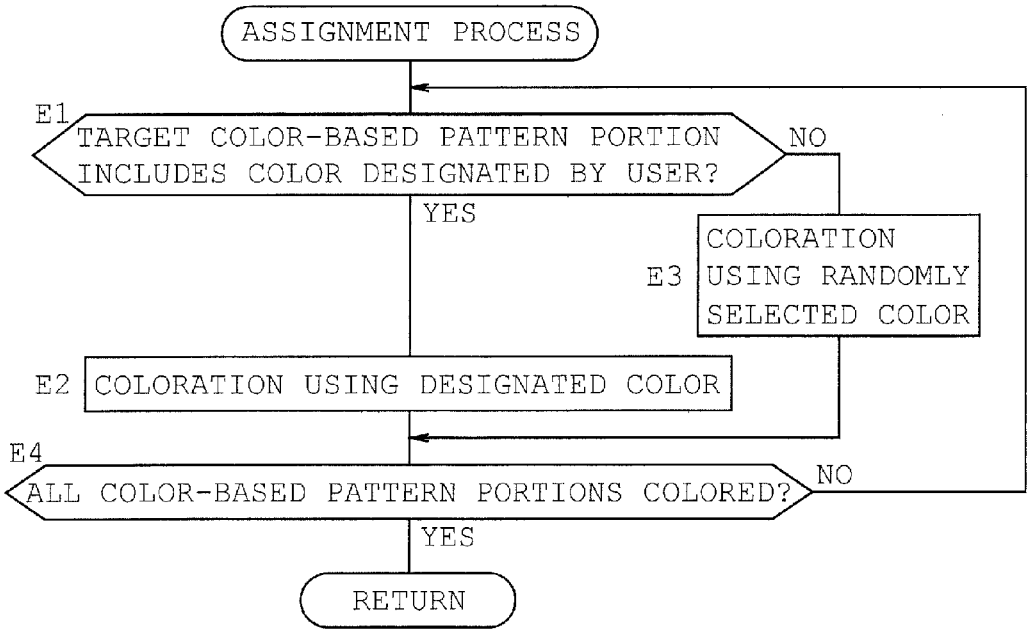

ASSIGNMENT PROCESS
E1
TARGET COLOR-BASED PATTERN PORTION INCLUDES COLOR DESIGNATED BY USER?
NO
YES
E3
COLORATION USING RANDOMLY SELECTED COLOR
E2
COLORATION USING DESIGNATED COLOR
E4
ALL COLOR-BASED PATTERN PORTIONS COLORED?
NO
YES
RETURN

FIG.13

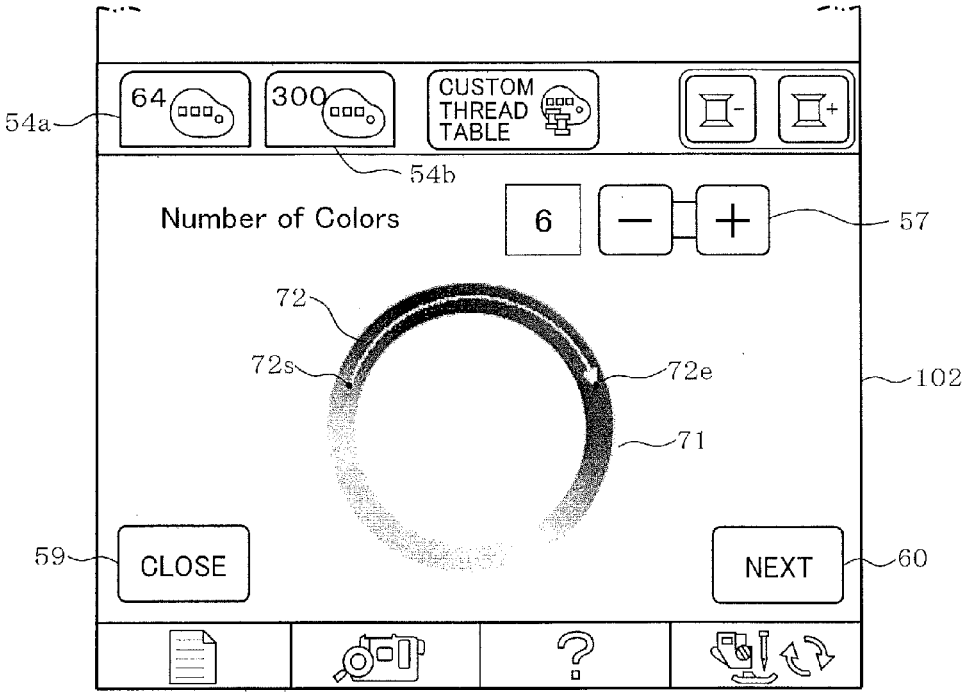


FIG.14A

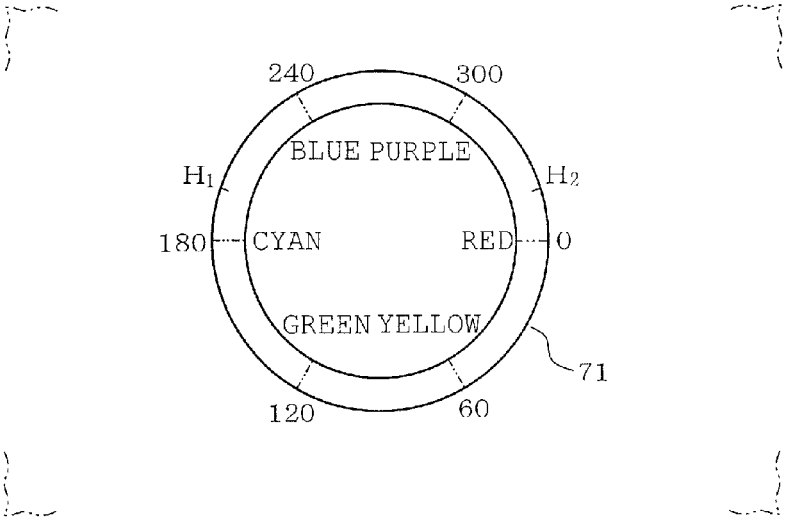


FIG.14B

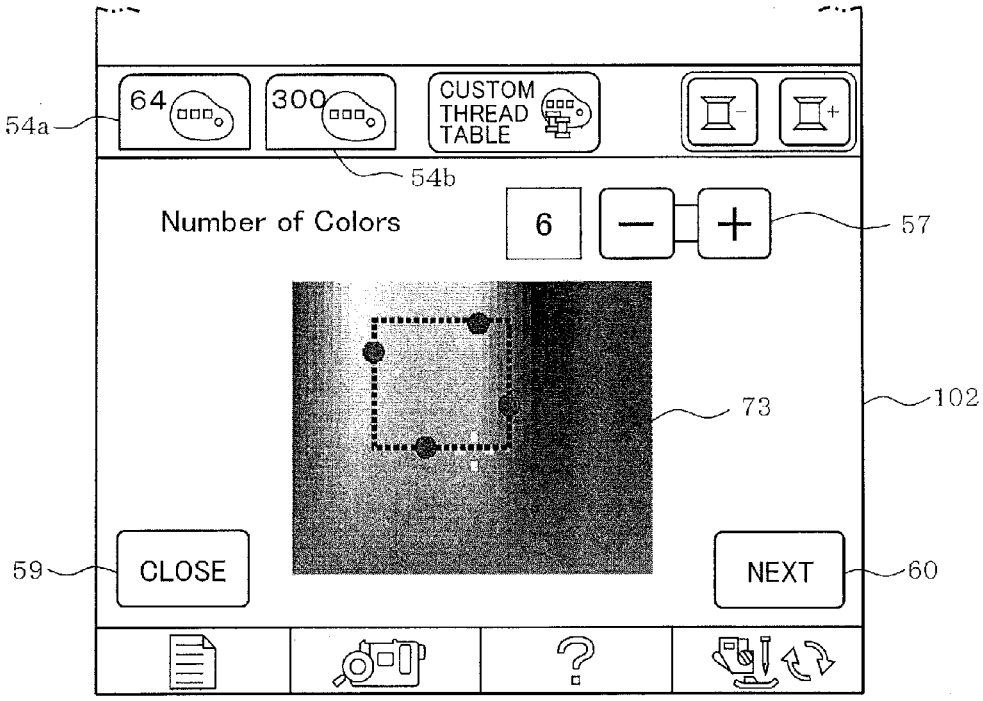


FIG.15A

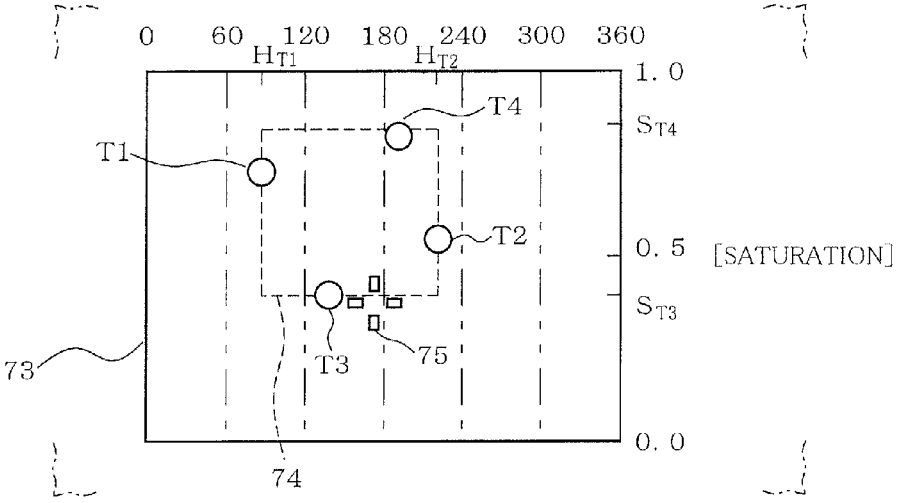


FIG.15B

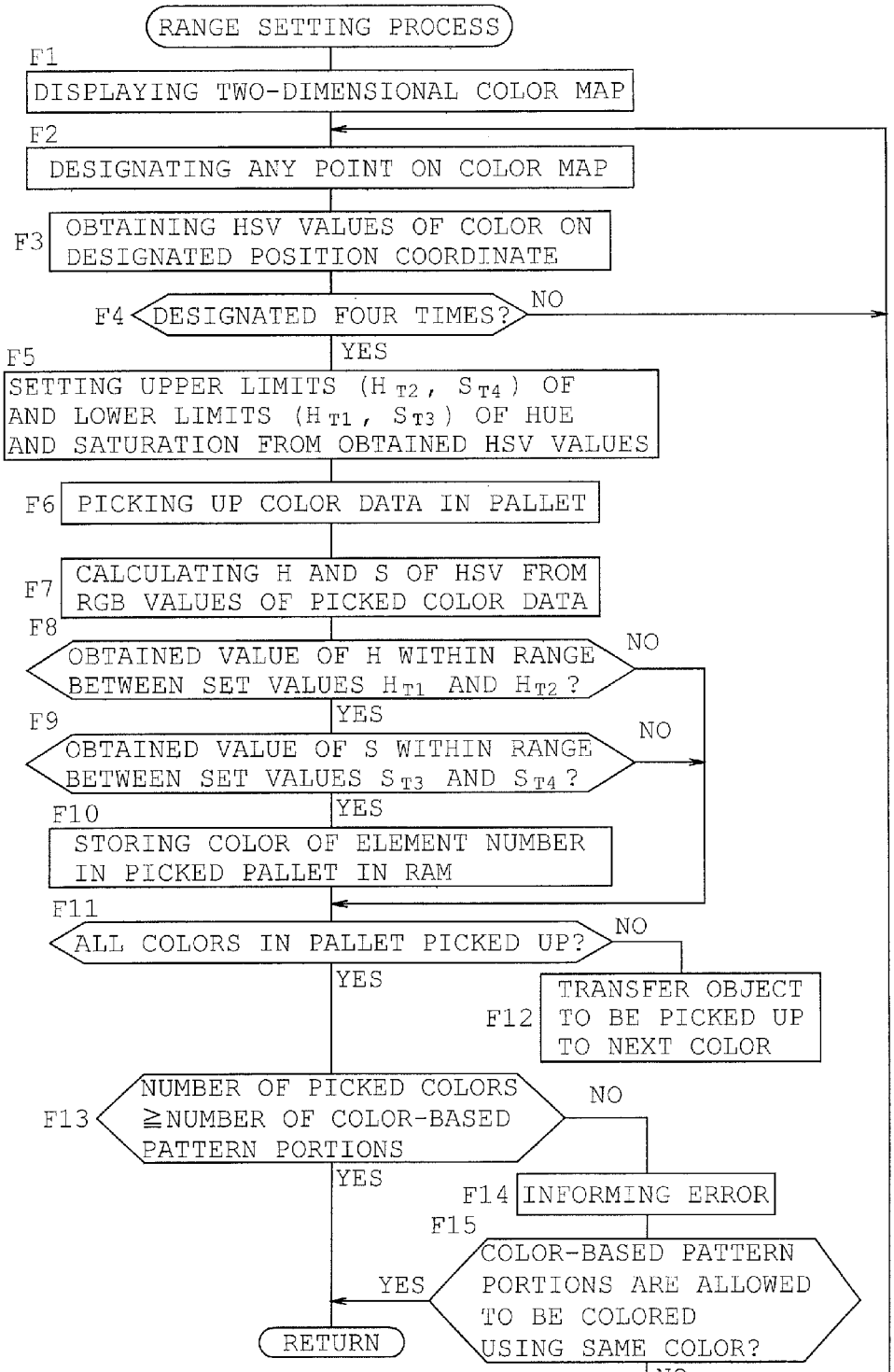

RANGE SETTING PROCESS
F1
DISPLAYING TWO-DIMENSIONAL COLOR MAP
F2
DESIGNATING ANY POINT ON COLOR MAP
F3
OBTAINING HSV VALUES OF COLOR ON DESIGNATED POSITION COORDINATE
F4
DESIGNATED FOUR TIMES?
NO
YES
F5
SETTING UPPER LIMITS (H_{T2}, S_{T4}) OF AND LOWER LIMITS (H_{T1}, S_{T3}) OF HUE AND SATURATION FROM OBTAINED HSV VALUES
F6
PICKING UP COLOR DATA IN PALLET
F7
CALCULATING H AND S OF HSV FROM RGB VALUES OF PICKED COLOR DATA
F8
OBTAINED VALUE OF H WITHIN RANGE BETWEEN SET VALUES H_{T1} AND H_{T2}?
NO
YES
F9
OBTAINED VALUE OF S WITHIN RANGE BETWEEN SET VALUES S_{T3} AND S_{T4}?
NO
YES
F10
STORING COLOR OF ELEMENT NUMBER IN PICKED PALLET IN RAM
F11
ALL COLORS IN PALLET PICKED UP?
NO
YES
F12
TRANSFER OBJECT TO BE PICKED UP TO NEXT COLOR
F13
NUMBER OF PICKED COLORS ≧NUMBER OF COLOR-BASED PATTERN PORTIONS
NO
YES
F14
INFORMING ERROR
F15
COLOR-BASED PATTERN PORTIONS ARE ALLOWED TO BE COLORED USING SAME COLOR?
YES
NO
RETURN

FIG.16

EMBROIDERY DATA GENERATOR, SEWING MACHINE AND NON-TRANSITORY COMPUTER-READABLE STORAGE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2013-243929 filed on Nov. 26, 2013, the entire contents of which are incorporated herein by reference.

BACKGROUND

1. Technical Field

The present disclosure relates to an embroidery data generator generating embroidery data, a sewing machine and a non-transitory computer-readable storage medium.

2. Related Art

There has conventionally been known a sewing machine which sews an embroidery pattern based on embroidery data. A plurality of data of embroidery patterns is stored in a storage device incorporated in the sewing machine or an external storage device such as ROM card or flexible disc. A user selects a desirable one of the embroidery patterns. The sewing machine enters the embroidery data of the selected embroidery pattern and sews the embroidery pattern on a workpiece cloth, while transferring an embroidery frame holding the workpiece cloth by a transfer mechanism.

An embroidery pattern includes a plurality of color-based pattern portions. Embroidery data of the embroidery pattern includes thread color data specifying a color of each color-based pattern portion. Each color-based pattern portion is sewn in a set color (a thread color) as thread color data. However, the user sometimes wishes to sew an embroidery pattern in favorite colors which do not correspond with the predetermined colors or in eccentric colors regarding the colors of the color-based pattern portions. When colors of the embroidery pattern are specified in this manner, data of the color-based pattern portions are required to be read one by one. Regarding each read data, the corresponding thread color data needs to be confirmed and specified, with the result that the color editing manner is time-consuming and troublesome.

SUMMARY

A conventional embroidery data generator is configured to automatically extract and assign a color to be used as thread color from a plurality of colors stored in a storage unit, for every thread color data of the color-based pattern portion.

More specifically, when the color of each color-based pattern portion of an embroidery pattern is set to a new one, the user selects one of "vivid," "soft" and "gradation" regarding a color category. Each one of the color categories is set as a threshold indicative of a color range as an HSV color model. For example, in the category of "soft," a threshold is set so that the difference between saturation values of an extracted color becomes smaller. When the user selects the category of "soft," the embroidery data generator carries out color extraction from the color range. The embroidery data generator assigns extracted color to every thread color data of each color-based pattern portion. Coloration is automatically carried out so that an entire embroidery pattern exhibits soft color shades.

However, the aforementioned threshold is a predetermined value. Accordingly, there is a case where the color extracted from the color range would not correspond to that desired by the user. Accordingly, there is a possibility that a coloration pattern the user desires for the embroidery pattern cannot be obtained.

Therefore, an object of the disclosure is to provide an embroidery data generator which can easily provide a variety of coloration patterns using colors the user desires for an embroidery pattern, a sewing machine and a non-transitory computer-readable storage medium.

The present disclosure provides an embroidery data generator generating embroidery data on which an embroidery pattern is sewn, the generator including a display unit configured to be capable of color display and a control device configured to cause the display unit to display a color chart representing at least one of three attributes of hue, saturation and value of a color in an HSV color space, to set a range on the displayed color chart, to randomly extract one of colors within the set range, the one color being used as thread color data, the embroidery pattern including a plurality of color-based pattern portions, the thread color data specifying colors of the color-based pattern portions, and to assign the extracted color to the thread color data of a corresponding one of the color-based pattern portions.

The disclosure also provides a non-transitory computer-readable storage medium storing a program for an embroidery data generator including a display unit capable of color display and a control device, the program causing the control device to execute instructions which, when executed, cause the control device to cause the display unit to display a color chart representing at least one of three attributes of hue, saturation and value of a color in an HSV color space, to set a range on the color chart displayed by the display unit, to randomly extract one of colors within the set range, the one color being used as thread color data, the embroidery pattern including a plurality of color-based pattern portions, the thread color data specifying colors of the color-based pattern portions, and to assign the extracted color to the thread color data of a corresponding one of the color-based pattern portions.

The disclosure further provides a sewing machine comprising a sewing unit capable of executing sewing on a workpiece cloth, a display unit capable of color display, and a control device configured to cause the display unit to display a color chart representing at least one of three attributes of hue, saturation and value of a color in an HSV color space, to set a range on the color chart displayed by the display unit, to randomly extract one of colors within the set range, the one color being used as thread color data, the embroidery pattern including a plurality of color-based pattern portions, the thread color data specifying colors of the color-based pattern portions, to assign the extracted color to the thread color data of a corresponding one of the color-based pattern portions, and to control the sewing unit so that an embroidery pattern is sewn on the workpiece cloth, based on embroidery data of the embroidery pattern including color-based pattern portions to which the extracted colors have been assigned respectively.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a perspective view showing an appearance of the sewing machine according to one embodiment;

FIG. **2** is a block diagram showing an electrical arrangement of the sewing machine;

FIG. **3** is a conceptual diagram showing a storage area of RAM of the sewing machine;

FIG. **4** illustrates an example of embroidery data;

FIG. **5** illustrates a first color change screen;

FIGS. **6**A and **6**B illustrate a range setting screen and a hue bar in the screen respectively;

FIG. **7** illustrates a thumbnail display screen;

FIG. **8** illustrates an enlarged display screen;

FIG. **9** is a flowchart showing setting of thread color data;

FIG. **10** is a flowchart showing a range setting process;

FIG. **11** is a flowchart showing a coloring process;

FIG. **12** is a flowchart showing an additional selecting process;

FIG. **13** is a flowchart showing an assigning process;

FIGS. **14**A and **14**B are views similar to FIGS. **6**A and **6**B, showing a second embodiment, respectively;

FIGS. **15**A and **15**B illustrate a lower half of range setting screen and a color map in the screen, showing a third embodiment, respectively; and

FIG. **16** is a view similar to FIG. **10**.

DETAILED DESCRIPTION

A first embodiment of a household sewing machine (hereinafter, "sewing machine M") will be described with reference to FIGS. **1** to **13**. Referring to FIG. **1**, the sewing machine M includes a bed **1** extending in a right-left direction, a pillar **2** standing from a right end of the bed **1** and an arm **3** extending leftward from an upper part of the pillar **2**, all of which are formed integrally with one another. The arm **3** houses a sewing machine shaft (not shown) extending in the right-left direction. A sewing machine motor **4** (see FIG. **2**) which rotates the machine shaft is provided in the pillar **2**. The side where the user is located relative to the sewing machine M, namely, the side of switches or a display unit will be referred to as "front" and the side opposed to the front will be referred to as "rear." The side where the pillar **2** is located will be referred to as "right side" and the side opposed to the right side will be referred to as "left side."

The arm **3** has a distal end on which are mounted a needle bar **5***a* having a lower end to which a needle **5** is attached and a presser bar **6***a* having a lower end provided with a presser foot **6**. The arm **3** houses a needle bar driving mechanism, a needle bar swinging mechanism, a needle thread take-up driving mechanism, a presser bar driving mechanism and the like although none of them are shown. The needle bar driving mechanism moves the needle bar **5***a* upward and downward based on rotation of the machine shaft. The needle bar swinging mechanism swings the needle bar **5***a* in a direction (the right-left direction) perpendicular to a cloth feed direction. The needle thread take-up driving mechanism moves a needle thread take-up (not shown) upward and downward in synchronization with the upward and downward movement of the needle bar **5***a*. The presser bar driving mechanism moves the presser bar **6***a* upward and downward.

The arm **3** is provided with a cover **3***a* which is pivotally mounted thereon to open and close an upper surface side thereof. A housing space **10***a* is defined in the central front of the arm **3** so as to house a thread spool **10** when the cover **3***a* is in an open state. A needle thread drawn from the thread spool **10** is supplied to the needle **5** through a thread supply passage including the needle thread take-up and the like. On the front side of the arm **3** are mounted various switches including a start/stop switch **8***a* and a speed adjusting knob **8***b*. The start/stop switch **8***a* is operable to start or stop a sewing work. The speed adjusting knob **8***b* is operable to adjust a sewing speed or a rotational speed of the machine shaft.

A large sized vertically long color liquid-crystal display **9** capable of full color display is provided on the front of the pillar **2**. The display **9** serves as a display unit displaying information by multiple colors. The display **9** is configured to display various sewing patterns such as ordinary patterns or embroidery patterns and names of functions to be executed in the sewing work. The display **9** is also configured to display a setting screen for setting regarding a coloration process as will be described later, and the like. The display **9** has a front to which is mounted a touch panel **9***a* (see FIG. **2**) having a plurality of touch keys including transparent electrodes. The touch keys are depressed by user's finger or a touch pen (not shown). The depression of the touch keys will hereinafter be referred to as "touch operation." Thus, selection of an embroidery pattern, instructions of various functions, setting of various parameters or the like is realized by the touch operation.

The pillar **2** has a right side surface formed with a card slot **12** (see FIG. **2**) into which a memory card **11** storing embroidery data of various embroidery patterns and the like is insertable.

The bed **1** has an upper surface on which a needle plate (not shown) is mounted. The bed **1** houses a cloth feed mechanism, a horizontal rotating hook, a thread cutting mechanism and the like, all of which are located under the needle plate. The cloth feed mechanism moves a feed dog vertically and horizontally. The horizontal rotating hook housing a bobbin forms stitches in cooperation with the needle **5**. The thread cutting mechanism cuts a needle thread and a bobbin thread.

An embroidery frame transfer device **13** is detachably attached to a left part of the bed **1**. The embroidery frame transfer device **13** includes a body **14** that is level with the upper surface of the bed **1** in an attached state thereof and a movable portion **15** which is mounted on an upper surface of the body **14** so as to be movable in the right-left direction. The movable portion **15** is provided with a carriage **17** which is movable in the front-back direction to detachably connect an embroidery frame **16** thereto. The embroidery frame **16** is configured to hold a workpiece cloth CL serving as an object to be sewn. In the body **14** is provided an X-direction transfer mechanism (not shown) which moves the carriage **17** in the right-left direction together with the movable portion **15** and a Y-direction transfer mechanism (not shown) which moves the carriage **17** in the front-back direction. The X-direction and Y-direction transfer mechanisms are provided with respective drive motors (an X-axis motor **18** and a Y-axis motor **19** as will be described later; and see FIG. **3**). The embroidery frame **16** is moved in the right-left or X direction and in the front-back or Y direction by driving the respective drive motors on the basis of the embroidery data of the embroidery pattern. The X-direction and Y-direction transfer mechanisms constitute a sewing unit for sewing an embroidery pattern, together with the needle bar driving mechanism and the presser bar driving mechanism.

The arrangement of a control system of the sewing machine M will now be described with reference to the block diagram of FIG. **2**. A control device **21** is configured mainly with a microcomputer and incorporates a CPU **22**, a ROM **23**, a RAM **24**, an EEPROM **25**, the card slot **12**, an input interface **27***a*, an output interface **27***b*, a bus bar **28** connecting between the input and output interfaces **27***a* and **27***b*, and the like. The start/stop switch **8***a* and the touch panel **9***a* are connected to the input interface **27***a*. To the output interface **27***b* are connected drive circuits **31**, **32**, **33** and **34** driving the sewing machine motor **4**, the X-axis motor **18**, the Y-axis motor **19** and the display **9** respectively. The control device **21**, the display **9** and the drive circuit **34** serve as a display unit. An embroidery data generator **30** is comprised of the control device **21**, the touch panel **9***a*, the display **9** and the drive circuit **34**.

The ROM **23** stores embroidery data, an embroidery data generating program, a sewing control program, a display control program and a table of full thread information. The embroidery data generating program causes the computer to function as various processing units to generate embroidery data. The full thread information table relates to all pieces of information about a plurality of types of threads used for embroidery sewing and includes thread color information as will be described later. The display control program is used to control the display **9**. These programs and data may be stored by another storage unit. The storage unit may include an internal storage unit such as an EEPROM **25** and an external storage unit such as the memory card **11**. For example, when the embroidery data generating program is stored in the external storage unit, the control device **21** reads the program onto the RAM **24** to execute the program.

The RAM **24** has a storage area for temporarily storing the aforementioned programs and data. The RAM **24** also has storage areas for storing various set values supplied by operation on the touch panel **9***a* and the like and results of calculation performed by the control device **21** and the like. In more detail, as shown in FIG. **3**, the RAM **24** has a program storage area **241**, a setting storage area **242**, an embroidery data storage area **243**, a flag storage area **244**, a sewing condition storage area **245**, a color information storage area **246**, an image display data storage area **247**, a work area **248**, an extracted data storage area **249** and the like. The program storage area **241** stores various programs read from the ROM **23** or the like. The setting storage area **242** stores settings, tables and the like referred to during execution of a program. The embroidery data storage area **243** stores data serving as an original or a reference value in generation of a color of embroidery data. The flag storage area **244** stores various flags used in execution of a program. The sewing condition storage area **245** stores various sewing conditions in the case of sewing an embroidery pattern.

The color information storage area **246** stores data used for coloration of an embroidery pattern and more specifically, a pallet table and pallet-based color numbers both of which will be described later, and the like. Furthermore, the extracted data storage area **249** temporarily stores data of a color randomly extracted from the pallet table or the like. The image display data storage area **247** stores image data of screens to be displayed on the display **9** and display settings. The work area **248** preliminarily stores settings and the like during execution of various programs.

An embroidery pattern **40** of "flower" displayed on a screen **104** of the display **9** as shown in FIG. **8** will be described as an example of embroidery pattern. The embroidery pattern **40** includes first to n-th pattern portions **401** to **40***n* which are a plurality of (n number of) color-based pattern portions. More specifically, for example, a first pattern portion **401** composing flower petal is sewn by the use of a purple thread. A second pattern portion **402** composing a leaf is sewn by the use of a yellow-green thread. A third pattern portion **403** composing a stalk is sewn by the use of a green thread. Thus, although the pattern portions **401** to **40***n* are color-based pattern portions for which respective colors are set, the pattern portions **401** to **40***n* may or may not have colors different from one another.

Embroidery data is used for the sewing machine M to sew an embroidery pattern and includes data of a plurality of color-based pattern portions. For example, as shown in FIG. **4**, embroidery data of the embroidery pattern **40** includes data of a plurality of needle locations set for respective pattern portions **401** to **40***n*, sewing sequence data to specify a sewing sequence of the pattern portions **401** to **40***n* and thread color data. The thread color data is also used to specify a color for every color-based pattern portion, and a color of the thread color data is assigned from color information to the thread color data by an assignment unit which will be described later.

An uppermost sewing sequence data "pattern **1**" in FIG. **4** is to specify a sequence of pattern to be initially sewn. "Purple" corresponding to the sequence is actually thread color data indicated by RGB values, for example. Furthermore, needle location data "Xa**0**, Ya**0**" . . . "XaN, YaN" is position coordinates where a needle corresponding to a purple thread sequentially drops. In the same manner, each of second and subsequent embroidery data includes sewing sequence data "pattern **2**" to "pattern n," thread color data "yellow-green" to "yellow" and needle location data "XbN, YbN" to "XnN, YnN." Furthermore, the embroidery data includes image data to be displayed on the display **9** (image data of bmp or the like, for example), and an image of embroidery pattern is displayed on the display **9** in colors assigned to respective thread color data.

The EEPROM **25** stores information (color information) about a plurality of colors assigned as thread color data. The EEPROM **25** and the RAM **24** each serve as a color storage unit. Color information relates to thread colors of thread spools **10** which can be used with the sewing machine M and is defined as RGB values. More specifically, the EEPROM **25** stores a first pallet table (see a first color pallet **53** in FIG. **5**) composed of RGB values of sixty-four colors and pallet-based color numbers of 1 to 64 corresponding to the respective RGB values. The EEPROM **25** also stores a second pallet table (not shown) of a plurality of colors selected from the color information by the user in addition to the first pallet data. The second pallet table is a custom pallet table including RGB values of up to three-hundred colors and pallet-based color numbers of 1 to 300 corresponding to the respective RGB values, both of which values are settable according to user's preference.

Screens displayed on the display **9** in generating embroidery data or in particular, coloration of thread color data will be described with reference to FIGS. **5** to **8** in addition to FIGS. **1** to **4**. FIGS. **5** to **8** explain display screens **101** to **104** of the display **9**. Since the display **9** is a liquid crystal color display, images of embroidery patterns, the first color pallet **53**, and the like on the screens **101** to **104** are displayable in multiple colors.

FIG. **5** exemplifies the first color change screen **101** displayed in the coloration of thread color data. The first color change screen **101** is provided with a preview image area **51** and a thread color data designation area **52**, the first color pallet **53**, a plurality of pallet selecting keys **54***a* and **54***b* and a shuffle key **55**. A preview image displayed in the preview image area **51** shows a result of embroidering in the case where embroidering is executed based on the embroidery data corresponding to an embroidery pattern selected by the user.

Various settings regarding a thread color are settable on the first color change screen **101**. More specifically, the thread color data designation area **52** shows colors corresponding to color-based pattern portions of the embroidery pattern in the preview image area **51**, together with an illustration of the thread spool **52***a*. When touching the touch key corresponding to the thread spool **52***a*, the user can designate a desirable color in the first color pallet **53** for every color-based pattern portion. For example, the first color pallet **53** has a top row to which RGB values of pallet-based color numbers 1 to 8 of the first pallet table are assigned sequentially from the left one respectively, as shown in FIG. **5**. Thus, the first color pallet **53**

is a 64-color pallet in which eight pieces of color information are assigned to each of eight rows from the top row to the bottom row.

A second color change screen provided with a second color pallet is prepared separately from the first color change screen although not shown. The second color pallet of the second color change screen has 300 squares capable of arranging up to 300 colors in 300 squares on the basis of the RGB values of the color information. The second color pallet thus corresponds to the second pallet table. When one of a pair of pallet selecting keys **54***a* and **54***b* is touched, the display **9** is switched between the first color change screen **101** and the second color change screen. When the shuffle key **55** is touched, the display **9** is switched to a range setting screen **102** as shown in FIG. **6**A.

The range setting screen **102** is also provided with a preview image area **51** and the like as the first color change screen **101**. The range setting screen **102** is further provided with a color number setting part **57**, a hue bar **58**, a CLOSE key **59** and a NEXT key **60**, instead of the first color pallet **53**. A total number of types of colors used as thread color data of embroidery data is set when a plus sign key and/or a minus sign key is touched. The total number has an upper limit that is a total number of color-based pattern portions in the embroidery pattern (corresponding to "n" in FIG. **4**) and a lower limit of "1." For example, when the color number setting part **57** is set at six colors as shown in FIG. **6**A, the embroidery pattern is colored using the six colors.

The hue bar **58** is a color chart made by developing a hue circle into a bar shape, as will be described in detail later. When any point, for example, two points on the hue bar **58** are designated by the touch operation, a range between the two points on the hue bar **58** is set. When the CLOSE key **59** is touched, the display **9** returns to the first color change screen **101**. When the NEXT key **60** is touched, a color is randomly extracted as thread color data from colors within the range set on the hue bar **58**. Subsequently, the display **9** is switched to a thumbnail display screen **103** as shown in FIG. **7**.

The thumbnail display screen **103** is provided with an embroidery pattern selection area **61** in which a plurality of embroidery patterns (six, for example) is displayed, a RETURN key **62**, a SAVE key **63**, a REFRESH key **64** and the like. The embroidery pattern selection area **61** displays thumbnail images **61***a* obtained by scaling down the embroidery patterns. These thumbnail images **61***a* represent six embroidery patterns differing in the combination of colors generated using the colors randomly extracted as the thread color data. When the SAVE key **63** and one of the thumbnail image **61***a* are touched on the thumbnail display screen **103** in turn, embroidery data of an embroidery pattern corresponding to the touched thumbnail image **61***a* is stored in the EEPROM **25**. Furthermore, when the REFRESH key **64** is touched, newly extracted colors are assigned to the thread color data. As a result, the currently displayed six embroidery patterns are replaced by new six embroidery patterns. When the RETURN key **62** is touched, the display **9** returns to the range setting screen **102**. When one of the thumbnail images **61***a* of the embroidery patterns is touched, the display **9** is switched to an enlarged display screen **104** as shown in FIG. **8**.

The enlarged display screen **104** is provided with an enlarged image area **65**, a CLOSE key **66**, a SET key **67** and the like. An enlarged embroidery pattern is displayed in the colors assigned by an assignment process in the enlarged image area **65**. When the SET key **67** is touched, the embroidery data of the embroidery pattern is stored in the EEPROM **25** and the display **9** returns to the first color change screen **101**.

HSV values are also used in the embodiment in addition to the RGB values. The HSV values are defined by hue, saturation and value in an HSV space, corresponding to the RGB values. The hue bar **58** is configured as a setting unit which sets a range of color phase. More specifically, the HSV values are computed on the basis of RGB values by a known obtaining method and represented by values of hue H, saturation S and value V. In this case, the hue represents a type of color such as red, purple, blue, etc. and has a value ranging from 0 to 360, for example. The saturation represents color vividness and has a value ranging from 0.0 to 1.0. The value represents color brightness and has a value ranging from 0.0 to 1.0.

FIG. **6**B explains the hue bar **58**. Numerals 0 to 360 affixed below the hue bar **58** indicate values of hue H. In the hue bar **58**, the numerals are arranged from the leftmost "0" corresponding to red to "60" corresponding to yellow, "120" corresponding to green, "180" corresponding to cyan, "240" corresponding to blue, "300" corresponding to purple and "360" corresponding to red again, sequentially in this order. There is no demarcation between colors adjacent to each other. For example, a number of types of colors representing continuous hue changes exist between red and yellow. Each of saturation S and value V is set at 1.0 over an entire range of the hue bar **58**, for example. The RAM **23** stores hue H of each pixel of the hue bar **58** in image data of the hue bar **58** and the abscissa of the hue bar **58** in a correspondence relationship.

When the user designates two points on the hue bar **58** by a touch operation, the control device **21** specifies pixels of the two points on the hue bar **58** corresponding to coordinate values of the designated points, obtaining hues H**1** and H**2** of the respective pixels. As a result, the obtained hues H**1** and H**2** are set as thresholds to determine a range on the hue bar **58**. The control device **21** then calculates hues H for sixty-four colors of the first pallet table or for three hundred colors of the second pallet table. The control device **21** further selects colors whose calculated hues H are within the range between the thresholds H**1** and H**2**. The current hue table is updated to a designated one composed of the colors within the hue range desired by the user on the basis of the colors selected as described above and new correlated pallet-based color numbers.

The control device **21** generates random numbers using a function with the maximum pallet-based color number serving as an argument, regarding the designated hue table generated on the basis of the designation on the hue bar **58**. The control device **21** collates the pallet-based color numbers corresponding to the random numbers, extracting the colors of the corresponding pallet-based color numbers. The colors thus extracted in the random manner are assigned to the color-based pattern portions **401** to **40***n* as the thread color data.

Of three attributes of color, saturation is an index indicative of a chromatic color by a numerical value up to 1.0 according to a degree of vividness with an achromatic color being set at 0.0. Luminance is an index indicative of chromatic luminosity while an ideal white or a brightest color is represented by 1.0. A color chart is an image representing at least one of the attributes, hue, saturation and value in the embodiment. A color chart to designate ranges of saturation and value may be used, instead of the hue bar **58** as will be described in detail later.

The working of the embroidery data generating program will be described with particular attention to coloration relevant to the thread color data with reference to FIGS. **9** to **13**,

which are flowcharts showing the processing procedure the control device **21** executes based on the embroidery data generating program.

The user firstly touches the touch panel **9***a* so that the embroidery data is read from the ROM **23**, whereby the control device **21** causes the display **9** to display an embroidery pattern selecting screen (not shown) according to the embroidery data. The user then selects a desired one of a plurality of embroidery patterns on the pattern selecting screen by touch operation. The touch operation changes the display **9** to a first color change screen **101** displaying the selected embroidery pattern as shown in FIG. **5**. Various setting processes are carried out on the first color change screen **101** before coloration of the embroidery pattern (step A**1** in FIG. **9**).

More specifically, when not wishing to change the colors of the color-based pattern portions of the embroidery pattern in a preview image area of the first color change screen **101**, the user designates the colors of the thread spools **52***a* displayed in the corresponding thread color data designating area **52** by touch operation. The colors designated in this manner are stored in an extracted data storage area **249**. An upper limit of designated number of colors equals the total number of color-based pattern portions of the embroidery pattern. Accordingly, when determining that color designation has been carried out with respect to all the color-based pattern portions at step A**1**, the control device **21** ends the processing although the ending is not shown.

Thread color data corresponding to the thread spools **52***a* in the thread color data designating area **52** can be designated using the first color pallet **53** or the second color pallet. In this case, the second color pallet (second color change screen) can be displayed when a pallet selection key **54***b* is touched on the first color change screen **101**. When a SHUFFLE key **55** is then touched, the control device **21** causes the display **9** to transit from the first color change screen **101** or the second color change screen to a range setting screen **102**, proceeding to a range setting process at step A**2** (see FIG. **10**).

The control device **21** causes the display **9** to display the color number setting part **57** and the hue bar **58** on the range setting screen **102** (step B**1**). The user touches the plus sign key and/or the minus sign key to set a total number of types of colors to be used for coloration of the embroidery pattern. A hue range to be used for coloration of the embroidery pattern is set by two touch operations on the hue bar **58** (step B**2**). In more detail, when the first touch operation is carried out on the hue bar **58**, coordinate values are output from the touch panel **9***a*. The control device **21** specifies a pixel corresponding to the touch position on the image of the hue bar **58**, based on the output coordinate value and the image data of the hue bar **58** to obtain HSV values of the pixel (step B**3**). Assume now that the HSV values are H**1**, S**1** and V**1**. In this case, when yellow as shown in FIG. **6**B is designated, the values H**1**, S**1** and V**1** become "60," "1.0" and "1.0" respectively. When the second touching operation is then carried out (NO at step B**4**; and step B**2**), the control device **21** also specifies a pixel corresponding to the touch position to obtain HSV values of the pixel (step B**3**). Assume that the HSV values are H**2**, S**2** and V**2**. In this case, when purple in FIG. **6**B is designated, the values of H**2**, S**2** and V**2** are "300," "1.0" and "1.0" respectively.

When the touch operation is carried out twice on the hue bar **58** (YES at step B**4**), the control device **21** sets thresholds which become a lower limit and an upper limit of the range of the hue bar **58**, based on the obtained values (step B**5**). Since the saturation values and the luminance values in the image of the hue bar **58** are constant (S**1**=S**2**=V**1**=V**2**=1.0), the hue value H**1** is set as the threshold of the lower limit and the hue value H**2** is set as the threshold of the upper limit.

Since the first color change screen **101** transfers to the range setting screen **102** at step A**1**, assume that the control device **21** has set the first color pallet **53** as a pallet used for coloration. In this case, the control device **21** reads RGB values corresponding to pallet-based color number 1 of the first pallet table (step B**6**) to calculate a hue value H based on the read RGB values (step B**7**). The control device **21** then determines whether or not the calculated hue value H is within the range between the thresholds H**1** and H**2** (step B**8**). When the hue value H is within the range between the thresholds H**1** and H**2** regarding the color of pallet-based color number 1 (YES at step B**8**), the color of pallet-based color number 1 is stored in the color information storage area **246** of the RAM **24** (step B**9**). In other words, when the color of pallet-based color number 1 is located between yellow corresponding to the lower limit threshold H**1** and purple corresponding to the upper limit threshold H**2** in the hue bar **58**, the color of pallet-based color number 1 is stored in the color information storage area **246** by the control device **21**.

On the other hand, when determining at step B**8** that the hue value H is outside the range between the thresholds H**1** and H**2** (NO), the control device **21** proceeds to step B**10** without storing the color of pallet-based color number 1 in the color information storage area **246**. Regarding the color of pallet-based color number 2 (NO at step B**10**; and step B**11**), too, the control device **21** calculates a hue value H based on the read RGB values, in the same manner as the color of pallet-based color number 1 (step B**7**). The control device **21** determines whether or not the hue value H of the color of pallet-based color number 2 is within the range between the thresholds H**1** and H**2**, thereby determining whether or not the color of pallet-based color number 2 is stored in the color information storage area **246** (step B**8**). Steps B**7** to B**11** are repeated regarding the sixty-four colors in the first color pallet **53**, and the corresponding color is stored at step B**9** every time the control device **21** determines in the affirmative at step B**8**. As a result, the first pallet table is updated to a designated hue table of selected colors within the hue designated on the hue bar **58** to be stored in the color information storage area **246** together with a post-update pallet-based color number.

The control device **21** returns to step A**3** in FIG. **9** when having completed selection regarding the sixty-four colors in the first pallet **53** (YES at step B**10**). When the second color pallet is set as used for coloration, the same processes as regarding the first color pallet **53** are executed at steps B**1** to B**11**. In the following description, symbol p will designate a total number of the designated hue table subsequent to update of the pallet table, namely, execution of step B**10**.

The control device **21** proceeds to step A**3** to execute a coloration process on the basis of the above-described settings regarding the selected embroidery pattern. The coloration process starts when the NEXT key **60** is touched on the range setting screen **102** (see FIG. **11**). The control device **21** firstly proceeds to step C**1** to calculate the combination number A of coloration based on the number of colors (set coloration manner number x) set by the color number setting part **57** and the total number n of color-based pattern portions in the selected embroidery pattern.

In the embodiment, in order that six embroidery patterns having different modes of coloration may be displayed on the thumbnail display screen **103**, for example, the combination number A necessary for the display is calculated using mathematical combination. Accordingly, when the set coloration mode number x is 1 and a total number n of color-based pattern portions is also 1, for example, the combination num-

ber A is represented as pC1. The combination number A of embroidery pattern coloration modes bears a proportionate relationship to the total number p of colors in the pallet table (the designated hue table). When the total number p is not less than 2 and the set coloration mode number x is not than 3, the combination number A is not less than 6. In this case, the control device **21** determines in the negative at step C2, setting the generator so that six embroidery data are generated (step C3). Further, when determining at step C1 that the calculated combination number A is less than 6 (YES at step C2), a corresponding number of embroidery data is generated.

The control device **21** subtracts from the set coloration mode number x the number of color-based pattern portions whose colors are not desired to be changed. As a result, the control device **21** calculates the number i of types of colors to be extracted in one embroidery pattern. The control device **21** generates random numbers within the total number p of colors of the designated hue table in the color information storage area **246** and extracts colors in a random manner based on the random numbers. More specifically, when the total number p of colors of the designated hue table is 42, for example, random numbers 1 to 42 are generated (step C5). The control device **21** then checks pallet-based color numbers of the designated hue table corresponding to the generated random numbers, extracting colors (RGB values) corresponding to the relevant pallet-based color numbers (steps C6 and C7). When the extracted colors do not overlap the colors designated at step A1 (YES at step C8), the control device **21** causes the RAM **24** to store the extracted colors in the extracted data storage area **249** (step C9).

The control device **21** thus stores the extracted colors in the extracted data storage area **249** and updates the color type number i to i=i−1 every time of storage of an extracted color (step C10). Further, the control device **21** executes steps C5 to C7 regarding extraction of second and subsequent colors (YES at step C8). When the extracted second and subsequent colors do not overlap the previously extracted colors or the colors designated at step A1 (YES at step C8), the colors are stored and the subtraction of color type number i is carried out in the same manner as the first color. The control device **21** repeatedly executes the steps C5 to C10 until determining that the color type number i is not more than 0 (NO at step C11). As a result, the colors used for one embroidery pattern, that is, the colors designated at step A1 and the colors extracted at steps C5 to C11 are stored in the extracted data storage area **249** without overlap.

The control device **21** then calculates a deficiency number T that is a difference between the total color-based pattern portion number n and the set coloration mode number x (step C12). When determining that the deficiency number T is to occur (NO at step C13), the control device **21** proceeds to an additional selection process (step C14). More specifically, the control device **21** selects one or more colors from the extracted data storage area **249** at step D1 in the additional selection process in order that the color-based pattern portion number n may be equal to the number of colors in the extracted data storage area **249** on the premise of the coloration process. In this case, the control device **21** generates random numbers within the total number of colors stored in the extracted data storage area **249** in the same manner as described above, so that the control device **21** can select one or more colors from the colors in the storage area **249** in a random manner. The control device **21** additionally stores the selected colors in the extracted data storage area **249** (step D21) and updates the deficiency number T to T=T−1 (step D3). The control device **21** repeatedly executes steps D1 to D4 until determining that the deficiency number T is reduced to zero (NO at step D4). As a result, the colors the number of which is equal to the total color-based pattern portion number n are stored in the extracted data storage area **249**.

The control device **21** proceeds to an assignment process (step C15) when determining that the number of colors stored in the extracted data storage area **249** corresponds with the total color-based pattern portion number n (NO at step D4 or YES at step C13). In the assignment process, the control device **21** determines whether or not the user has designated a color (the designation at step A1) for every thread color data of color-based pattern portion (step E1), as shown in FIG. **13**. When the thread color data contains user's designation, a corresponding color is assigned (step E3), and a color extracted in the random manner is assigned when the thread data contains no designation. In the assignment, the control device **21** shuffles the colors stored in the extracted data storage area **249**. In other words, even when the additional selection process has been carried out and overlapping colors are stored in the extracted data storage area **249**, a rearranging process is carried out so that a plurality of colors in the extracted data storage area **249** is taken apart, with the result that randomicity is ensured in coloration. The control device **21** thus repeats steps E1 to E4 by the number of times corresponding to the number n of color-based pattern portions and then returns to step C16 in FIG. **11** when completing coloration.

When completing coloration of the first embroidery pattern by the above-described processing, the control device **21** causes the RAM **24** to store all the thread color data (YES at step C16; and step C17). The control device **21** then updates the combination number A into A=A−1 (step C18), returning to step C4 (YES at step C19). The control device also executes steps C4 to 015 regarding coloration of second and subsequent embroidery patterns. When determining that coloration of second and subsequent embroidery patters differs from the generated coloration of the first embroidery pattern (YES at step C16), the control device **21** carries out storing of thread color data and subtraction of combination number A in the same manner as the first embroidery pattern (steps C17 and C18). The control device **21** thus repeats steps C4 to C19 until the combination number A becomes not more than 0 (NO at step C19), with the result that combination number A of embroidery patterns differing in the coloration is generated. The control device **21** subsequently returns to step A4 in FIG. **9**.

The control device **21** causes the display **9** to display on the thumbnail display screen **103** the number A of thumbnail images (six in FIG. **7**C) of embroidery patterns differing in the coloration. These thumbnail images have a coloration pattern within the hue range desired by the user regarding each embroidery pattern since the coloration process has been executed for the thumbnail images using the designated hue table. Accordingly, when the range from yellow to purple is designated by the hue bar **58** regarding each embroidery pattern in the manner as described above, each embroidery pattern has no rubric colors and is thus colored with less flashy feel.

When any one of the thumbnail images **61***a* of embroidery patterns is touched, the display **9** transits from the thumbnail display screen **103** to the enlarged display screen **104** (YES at step A5; and step A6). The control device **21** causes the display **9** to display the embroidery pattern obtained by enlarging the selected thumbnail image on the enlarged display screen **104**. When the SET key **67** is subsequently touched, the control device **21** returns to the first color change

screen **101** displaying the embroidery pattern of the enlarged image area **65** as the embroidery pattern of the preview image (END).

When the RETURN key **62** is touched on the thumbnail display screen **103** (YES at step A**7**), the control device **21** proceeds to step A**2** where the range setting screen **102** is displayed.

Accordingly, various setting processes can be re-carried out so that the coloration process of the embroidery pattern is executed again. Further, when the REFRESH key **64** is touched (YES at step A**8**), the control device **21** proceeds to step A**3** to execute the coloration process of the embroidery pattern again. As a result, new extracted colors are assigned to the thread color data, so that new six embroidery patterns are displayed instead of the currently displayed embroidery patterns. On the other hand, when the SAVE key **63** is touched on the thumbnail display screen **103** (YES at step A**9**), the control device **21** proceeds to a save mode (step A**10**). When any one of thumbnail images **61***a* (or a plurality of thumbnail images) is touched to be selected in the save mode, the control device **21** stores embroidery data of the embroidery pattern in the EEPROM **25** (step A**11**).

The control device **21** executing the steps C**1** to C**19**, D**1** to D**4** and E**1** to E**4** serves as an extraction unit which randomly extracts colors to be used as thread color data and the assignment unit which assigns the extracted colors. The control device **21** also serves as a first display control unit and a second display unit and causes the display **9** to display the hue bar **58** serving as the color chart at step B**1**. The control device **21** causes the display **9** to display the embroidery pattern in the colors assigned to the thread color data of the respective color-based pattern portions at steps A**4** and A**6**. The control device **21** and the touch panel **9***a* serve as a setting unit which sets the range on the hue bar **58**. Further, the control device **21**, the touch panel **9***a* and the display **9** serve as a pattern selection unit which selects a desired embroidery pattern.

The sewing machine M of the embodiment includes the first display control unit which causes the display unit to display the color chart representing at least one of the three attributes of color, that is, hue, saturation and value, the setting unit which sets a range on the color chart displayed on the display unit, the extraction unit which randomly extracts the color used as the thread color data to specify the color of color-based pattern portion from colors within the range set by the setting unit and the assignment unit which assigns the color extracted by the extraction unit for every thread color data of color-based pattern portion.

According to the above-described configuration, a desired range is set on the color chart representing at least one of the three color attributes, that is, hue, saturation and value by the setting unit. The color extracted from those in the desired range is assigned to the thread color data of color-based pattern portion, with the result that a random coloration can be carried out. Coloration involving accidentalness or unpredictable quality can be generated within the color range desired by the user with the result that a variety of color patterns can be easily obtained.

The control device **21** and the touch panel **9***a* serve as a designation unit which designates at least two points on the color chart. A range on the color chart is set based on the designated points. According to this configuration, since the two points on the color chart are designated, the range can be easily set.

The color chart is the hue bar **58** formed by developing a hue circle into a bar shape or may be a hue circle **71** as will be described with reference to FIG. **14**A. Since the hue bar **58** or the hue circle **71** has a plurality of types of colors representing hue changes in orderly sequence, a hue range can be easily set. Further, an image of embroidery pattern can be varied and coloration with a sense of unity can be carried out over an entire embroidery pattern depending upon the hue range to be set.

Color extraction and color assignment are carried out by the extraction unit and the assignment unit regarding the embroidery pattern selected by the pattern selection unit, respectively. The second display control unit causes the display unit to display the embroidery pattern in the colors assigned to the thread color data of color-based pattern portions. According to this configuration, the colors of the color-based pattern portions in the generated embroidery data can be visually grasped in an easy manner.

Although the embroidery pattern before color assignment by the assignment unit and the color chart are displayed in juxtaposition on the same screen of the display **9** in the embodiment (see step B**1** and FIG. **6**A), the embroidery pattern after color assignment by the assignment unit and the color chart may be displayed in juxtaposition on the same screen of the display **9**. Thus, the first and second display control units cause the display **9** to display the embroidery pattern before or after color assignment together with the color chart on the same screen of thereof. According to this configuration, a color range or the like can be set according to the embroidery pattern with the result of improvement in the usability of the embroidery data generator.

FIGS. **14**A and **14**B illustrate a second embodiment. Only the differences between the first and second embodiments will be described. Identical or similar parts in the second embodiment are labeled by the same reference symbols as those in the first embodiment.

The range setting screen **102** is provided with the hue circle **71** as the color chart as shown in FIG. **14**A. FIG. **14**B explains the hue circle **71**. In the hue circle **71**, numerals are arranged clockwise from "0" corresponding to red, to "60" corresponding to yellow, "120" corresponding to green, "180" corresponding to cyan, "240" corresponding to blue, "300" corresponding to purple and "360" corresponding to red again sequentially in this order. There is no demarcation between colors adjacent to each other. Accordingly, a number of types of colors representing continuous hue changes exist between the adjacent colors in the same manner as the hue bar **58**. Each of saturation S and value V is set at 1.0 over an entire range of the hue circle **71**.

A hue range can be set on the hue circle **71** by a swiping operation as well as the above-described touch operation to designate two points. For example, when the user swipes the hue circle **71** by a finger in a direction of arrow **72** in FIG. **14**A, the control device **21** detects coordinate values of a start point and an end point of the swiping operation on the touch panel **9***a*, that is, two points (see symbols **72***s* and **72***e*) at the proximal end side and the distal end side of the arrow **72**. Based on the coordinate values of the detected points and the image data of the hue circle **71**, the control device **21** then specifies pixels corresponding to the respective points in the image of the hue circle **71**, thereby obtaining hue values H**1** and H**2** of the pixels. As a result, the obtained hue values H**1** and H**2** are set as thresholds to determine a range on the hue circle **71**.

Accordingly, the hue range can be easily set by designating two points on the hue circle **71** by the above-described operation. In particular, the hue circle **71** differs from the hue bar **58** in that the 300-degree purple is continuous with the 0-degree red in the hue circle **71**. Accordingly, the range can be designated with these hue values being involved. The hue circle should not be limited to the hue circle **71** which represents

continuous hue changes without demarcation between colors adjacent to each other. The hue circle may represent divided color regions of red, the yellow-red, yellow and so on, for example.

FIGS. **15**A, **15**B and **16** illustrate a third embodiment. Only the differences between the first and third embodiments will be described. Identical or similar parts in the third embodiment are labeled by the same reference symbols as those in the first embodiment.

The range setting screen **102** is provided with a two-dimensional color map **73** which represents two of three attributes of color, as shown in FIG. **15**A. The color map **73** is represented as a two-dimensional coordinate system having an abscissa axis indicative of hue value H and an ordinate axis indicative of saturation value S as shown in FIG. **15**B. More specifically, an image of the color map **73** represents hue along the abscissa axis from the left end 0-degree to the right end 360-degree and saturation increased along the ordinate axis from the lower end "0.0" to upper end "1.0." The color map **73** has a value V of HSV, which is set at 1.0, for example.

When four points are designated on the color map **73** by the touch operation, for example, a rectangular region range 74 is displayed according to touch positions T**1**, T**2**, T**3** and T**4**, as will be described in detail in the description of working later. The region range 74 has a left side and a right side corresponding to the touch positions T**1** and T**2** designating a lower limit HT**1** and an upper limit HT**2** of hue, respectively. The region range 74 further has a lower border and an upper border corresponding to the touch positions T**3** and T**4** designating a lower limit ST**3** and an upper limit ST**4** of saturation, respectively.

The following will describe a specific process flow using the color map **73** with reference to FIG. **16**, which is a flowchart showing a flow of range setting process executed by the control device **21**, instead of the above-described steps B**1** to B**11**. The control device **21** causes the display **9** to display the color map **73** on the range setting process screen **102** (step F**1**). When a first touch operation is carried out on the color map **73** (step F**2**), a coordinate value is output from the touch panel **9***a*. In this case, the control device **21** specifies a pixel corresponding to the touch position T**1** on the image of the color map **73** based on the output coordinate value and image data of the color map **73**, obtaining HSV values of the pixel (step F**3**). When a second touch operation is then carried out on the color map **73** (NO at step F**4**; and step F**2**), the control device **21** specifies a pixel corresponding to the touch position T**2** based on the output coordinate value and image data, obtaining HSV values of the pixel (step F**3**). The control device **21** thus repeats steps F**2** and F**3** until determining that the touch operation has been carried out at four times (YES at step F**4**).

The control device **21** sets a region range 74 of four touch positions T**1** to T**4** as shown in FIG. **15**B on the color map **73** based on the obtained HSV values (step F**5**). Since the value V of HSV is constant (V=1.0) in the third embodiment, a minimum hue HT**1**, a maximum hue HT**2**, a minimum saturation ST**3** and a maximum saturation ST**4** are selected from the obtained HSV values and set as thresholds with respect to the region range 74. As a result, the control device **21** causes the display **9** to display a range defined by the thresholds HT**1**, HT**2**, ST**3** and ST**4** on the color map **73**, that is, the rectangular region range 74 as shown by broken line in FIG. **15**B. FIG. **15**B exemplifies a case where the lower and upper limits HT**1** and HT**2** of hue are set by the first and second touch operations respectively and the lower and upper limits ST**3** and ST**4** are set by the third and fourth touch operations respectively.

For example, when the first color pallet **53** is set at step A**1**, the control device **21** reads RGB values corresponding to pallet-based color number 1 of the first pallet table (step F**6**). The control device **21** further calculates a hue value H and a saturation value S based on the RGB values (step F**7**). Subsequently, the control device **21** determines whether or not the obtained hue value H ranges between the thresholds HT**1** and HT**2** (step F**8**). The control device **21** further determines whether or not the obtained saturation value S ranges between the thresholds ST**3** and ST**4** (step F**9**). When determining that the hue value H ranges between the thresholds HT**1** and HT**2** and the saturation value S ranges between the thresholds ST**3** and ST**4** regarding the color of pallet-based color number 1 (YES at steps F**8** and F**9**), the control device **21** stores the hue value H and the saturation value S in the color information storage area **246** of the RAM **24** (step F**10**). In other words, the color of pallet-based color number 1 is stored in the color information storage area **246** when the color corresponds to the color within the region range 74 on the color map **73**.

On the other hand, assume now that the control device **21** determines that the hue value H is out of the range between thresholds HT**1** and HT**2** at step F**8** (NO) or that the saturation value S is out of the range between thresholds ST**3** and ST**4** at step F**9** (NO). In this case, the control device **21** proceeds to step F**11** without storing the hue value H and the saturation value S in the color information storage area **246** regarding the color of pallet-based color number 1. Regarding the color of pallet-based color number 2 (NO at step F**11**; and step F**12**), the control device **21** calculates a hue value H and a saturation value S in the same manner as the pallet-based color number 1, based on the read RGB values (step F**7**). The control device **21** determines whether or not the hue value H ranges between the thresholds HT**1** and HT**2** and whether or not the saturation value S ranges between the thresholds ST**3** and ST**4**, thereby determining whether or not the color of pallet-based color number 2 is stored in the color information storage area **246** (steps F**8** and F**9**). The control device **21** thus repeats steps F**7** to F**12** regarding sixty-four colors in the first color pallet **53** and stores the color at step F**10** every time determining in the affirmative at each one of steps F**8** and F**9**. As a result, the first pallet table is updated into a designated range table of the colors within the region range designated on the color map **73**. The designated range table is stored in the color information storage area **246** together with the updated pallet-based color numbers.

When completing the selection regarding all the sixty-four colors in the first color pallet **53** (YES at step F**11**), the control device **21** proceeds to step F**13** to determine whether or not the selected color number p is not less than the total number n of color-based pattern portions. When the selected color number p is less than the total number n of color-based pattern portions (NO at step F**13**), the control device **21** informs the user to that effect (step F**14**). In other words, the selected color number p is reduced when an erroneous touch operation renders the region range 74 smaller. The control device **21** may then cause the display **9** to display the message that "a part of the embroidery pattern is colored by the same color as used in another part." with sounding of error sound.

Alternatively, the control device **21** may cause the display **9** to display an indication to encourage the user to re-designate the region range 74. Assume now that the user would carry out an input operation (a touch operation) in response to the displayed contents. In this case, the control device **21** returns to step A**3** in FIG. **9** when determining that coloration using the same color between or among the color-based pattern portions is to be executed, based on the touch operation or the comparison between the set color combination number x

and the selected color number p (YES at step F15). On the other hand, the control device **21** returns to step F2 when determining that coloration using no same color between or among the color-based pattern portions is to be executed (NO at step F15). Accordingly, the user can designate the region range 74 again.

It is only necessary to execute the informing at step F14 when the selected color number p is smaller than the total number n of color-based pattern portions. For example, when the selected color number p is less than the total number n of color-based pattern portions, the control device **21** may return from step F15 to step F2 unconditionally.

Further, although the touch positions T1 to T4 are not displayed on the color map **73**, a cross-shaped cursor **75** as shown in FIG. **15**B may be displayed as an input position (a touch point), for example. Still further, a mouse may be detachably connected to a connector (not shown) provided on a side surface of the pillar **2** so as to be operable with the cursor **75** serving as a mouse cursor to set the region range 74.

The color map **73** in the third embodiment is represented as a two-dimensional coordinate system having two coordinate axes indicative of hue and saturation as described above. According to this configuration, the range on the color map **73** can be easily set regarding the attributes of hue and saturation with the result that user's color preference can be better reflected on the coloration of embroidery pattern.

The control device **21**, the display **9** and the drive circuit **34** serve as the informing unit which informs that the extractable number of colors is smaller than the number of thread color data of the color-based pattern portions when a color belonging to the range (the region range 74) designated by the designation unit is extracted from the color information stored in the storage unit by the extraction unit.

Steps F13 to F15 relating to the informing operation may be executed with respect to another color chart (after step B10 in the case of the hue bar **58**) as well as the color map **73**.

According to this configuration, an error in setting the range on the color chart can be informed and a suitable range according to the embroidery pattern (the number of thread color data of color-based pattern portions) can be set.

The foregoing embodiments should not be restrictive but may be modified or expanded as follows.

The embroidery data generator should not be limited to the construction provided in the sewing machine M but may be composed of a generator body which is a personal computer (a dedicated machine), a mouse, a keyboard, a memory card connector and a display all connected to the body, and the like. Further, when the sewing machine M and the embroidery data generator are constructed independently of each other, the sewing machine M and the embroidery data generator may be connected to each other in a wired or wireless connection manner so that data is transmitted and received therebetween.

The color chart represented by the two-dimensional coordinated system should not be limited to the color map **73** but may be a two-dimensional color map having two coordinate axes indicative of hue and saturation. In this case, the color map has an abscissa axis indicative of hue value H from 0 to 360 and an ordinate axis indicative of value V from 0.0 to 1.0 with saturation S being constant (**1.0**, for example). According to this configuration, the range can be easily set on the color map regarding the attributes of hue and saturation. Further, user's color preference can be better reflected on the coloration of embroidery pattern. Thus, this modified form can achieve the same effect as the third embodiment.

The setting unit and the designation unit should not be limited to the respective above-described configurations. For example, when two points are designated on the two-dimensional color map **73** by touch operation in the third embodiment, a rectangle having a diagonal obtained by connecting the points may be set as the region range 74.

The storage unit should not be limited to the RAM **24** and the EEPROM **25** but may be another internal storage unit incorporated in the sewing machine or the embroidery data generator or an external storage unit detachably attachable to the sewing machine or the embroidery data generator.

A storage medium storing the embroidery data generating program should not be limited to the ROM **23** but may be a USE memory, a CD-ROM, a flexible disc, a DVD, a memory card or the like. In this case, the embroidery data generating program may be read by a computer such as the foregoing dedicated machine to be executed. As a result, this modification can achieve the same working and advantageous effect each as that achieved by the foregoing embodiment.

The foregoing description and drawings are merely illustrative of the present disclosure and are not to be construed in a limiting sense. Various changes and modifications will become apparent to those of ordinary skill in the art. All such changes and modifications are seen to fall within the scope of the appended claims.

What is claimed is:

1. An embroidery data generator generating embroidery data on which an embroidery pattern is sewn, the generator comprising:

a display unit configured to be capable of color display; and

a control device configured to:

cause the display unit to display a color chart representing at least one of three attributes of hue, saturation and value of a color in an HSV color space;

set a range on the displayed color chart;

randomly extract one of colors within the set range, the one color being used as thread color data, the embroidery pattern including a plurality of color-based pattern portions, the thread color data specifying colors of the color-based pattern portions; and

assign the extracted color to the thread color data of a corresponding one of the color-based pattern portions.

2. The generator according to claim **1**, further comprising a designation unit configured to designate at least two points on the color chart and to set the range based on the designated points.

3. The generator according to claim **2**, wherein the color chart is a hue circle or a hue bar formed by developing the hue circle into a bar shape.

4. The generator according to claim **2**, wherein the color chart is a two-dimensional chart having two coordinate axes indicative of hue and saturation or hue and value in the HSV color space respectively.

5. The generator according to claim **2**, further comprising:

a storage unit configured to store a plurality of pieces of predefined color information; and

an informing unit configured to be capable of informing of information,

wherein the control device is further configured to:

compare a number of extractable colors with a number of the thread color data of the color-based pattern portions when the colors corresponding to colors within the designated range are extracted from the pieces of color information in the storage unit; and

cause the informing unit to inform that the number of extractable colors is smaller, when the number of extractable colors is smaller than the number of the thread color data of the color-based pattern portions.

6. The generator according to claim 1, wherein the color chart is a hue circle or a hue bar formed by developing the hue circle into a bar shape.

7. The generator according to claim 1, wherein the color chart is a two-dimensional chart having two coordinate axes indicative of hue and saturation or hue and value in the HSV color space respectively.

8. The generator according to claim 1, further comprising:

a pattern selection unit configured to select a desired one of a plurality of embroidery patterns,

wherein the control device is further configured to:

randomly extract a plurality of colors used as thread color data of the selected embroidery pattern respectively;

assign the extracted colors to the thread color data of a plurality of color-based pattern portions of the selected embroidery pattern respectively; and

cause the display unit to display the selected embroidery pattern in the colors assigned to the thread color data of the color-based pattern portions respectively.

9. The generator according to claim 8, wherein the display unit includes a display and the control device is further configured to cause the display to display the selected embroidery pattern before or after the color assignment and the color chart in juxtaposition on a same screen of the display.

10. A non-transitory computer-readable storage medium storing a program for an embroidery data generator including a display unit capable of color display and a control device, the program causing the control device to execute instructions which, when executed, cause the control device to:

cause the display unit to display a color chart representing at least one of three attributes of hue, saturation and value of a color in an HSV color space;

set a range on the color chart displayed by the display unit;

randomly extract one of colors within the set range, the one color being used as thread color data, the embroidery pattern including a plurality of color-based pattern portions, the thread color data specifying colors of the color-based pattern portions; and

assign the extracted color to the thread color data of a corresponding one of the color-based pattern portions.

11. A sewing machine comprising:

a sewing unit capable of executing sewing on a workpiece cloth;

a display unit capable of color display; and

a control device configured to:

cause the display unit to display a color chart representing at least one of three attributes of hue, saturation and value of a color in an HSV color space;

set a range on the color chart displayed by the display unit;

randomly extract one of colors within the set range, the one color being used as thread color data, the embroidery pattern including a plurality of color-based pattern portions, the thread color data specifying colors of the color-based pattern portions;

assign the extracted color to the thread color data of a corresponding one of the color-based pattern portions; and

control the sewing unit so that an embroidery pattern is sewn on the workpiece cloth, based on embroidery data of the embroidery pattern including color-based pattern portions to which the extracted colors have been assigned respectively.

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